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DEVOTED TO THE CONVERSION, TRANSMISSION and DISTRIBUTION OF ENERGY.

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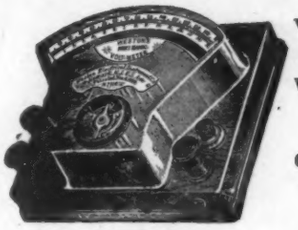

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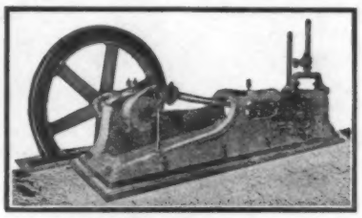

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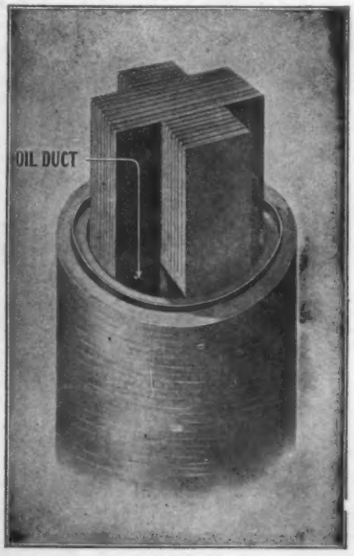

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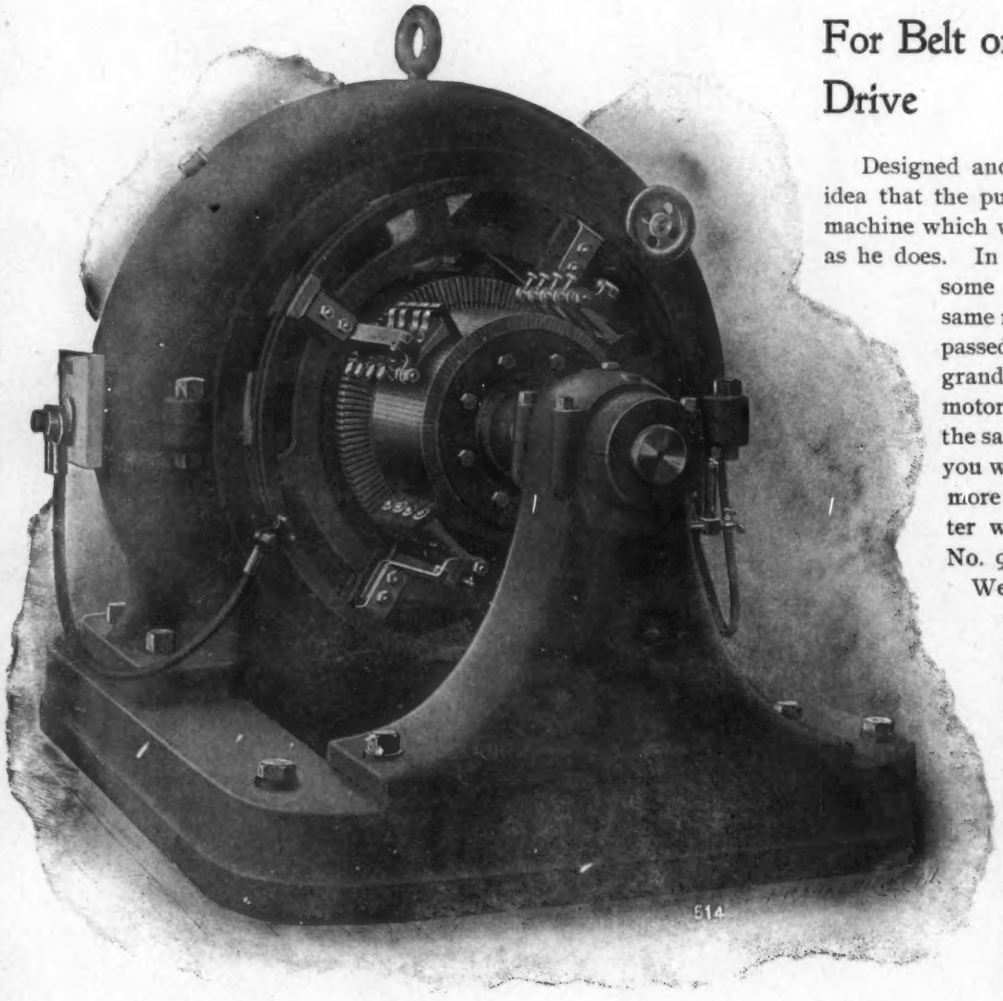

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The Journal of Electricity, Power and Gas.

Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XIII. SAN FRANCISCO, CAL., FEBRUARY, 1903. NUMBER 2

The Distribution of Bay Counties' Power.

Most important and far-reaching of all the industrial organizations which have been effected on the Pacific Coast of late is that whereby the California Gas and Electric Corporation acquires all the properties and interests of the Bay Counties Power Company, the Valley Counties Power Company, the California Central Gas and Electric Company, the Sacramento Electric, Gas and Railway Company, the Oakland Gas, Light and Heat Company, the Fresno Gas and Electric Company, and perhaps a score of other smaller companies mainly of local importance, yet which in the aggregate comprise the entire electric lighting, power and railway, as well as the entire gas lighting and heating, interests of fourteen of the most populous and most productive counties of the State of California.

With the completion of its new power plants, this great corporation will be prepared to deliver 69,000 horsepower to its transmission lines, and how this power is utilized will be related in the series of articles which will appear from time to time and of which the following is the beginning.—THE EDITOR.

MARYSVILLE, the county seat of Yuba County, Cal., a city of some 5000 inhabitants and which has tributary to it not only Yuba County, but also the greater portions of Yolo and Colusa counties, is in the midst of one of the best and most productive horticultural sections of the State of California. Its early history is that of the Argonaut days of the rush of gold seekers in the 'fifties, for then Marysville was second in importance to Sacramento as a base of mining supplies. All stage lines centered there, and today, if the traveler is so fortunate as to travel over the roads of Yuba County with one who is familiar with its history, one will find unceasing interest in the history that will be related about the enormous quantities of the precious metal which were brought into Marysville over this particular road, of the once famous diggings which formerly existed in that canyon yonder, and of the hold-up of the Placerville stage which occurred right here at this particular bend of the road in '56, when three outlaws relieved the stage of "more than twenty thousand in dust, besides killing five men." But now the soil is worked for the profit of the tree and the vine, the stage routes of old are simply county roads, and the only reminders which exist of the mining activity of yore are the great levees that the farmers have thrown up to protect their tens of thousands of acres of tillable ground from floods due to the shoaling of the beds of the Yuba and Feather rivers during the days when the soil of foothill after foothill was washed down from the mountains and deposited in the channels of the Feather and the Sacramento and the Stanislaus and the Yuba rivers below. And when the winter rains come down with their raging torrents man struggles with Nature to relieve the floods, each upon the lands of the other. Indeed during periods of extreme freshets it is an every winter's occurrence for farmers, armed to the teeth, to patrol the levees on each side of the river in order to prevent those of the opposite side from relieving the flood by breaking the other's levee. Thus is given even today in strenuous realism a living aftertaste of the spirit of the days of '49.

The region to the west of Marysville immediately across the Feather River in Yolo County is noted as the finest peach-growing section of the State, and so superb is the quality of its products that the minimum diameter of any peach which will be accepted for canning by the packers of Marysville is three and one-half inches. And the quality of the fruit is commensurate with its size.

THE LATE MR. D. E. KNIGHT

A PANORAMIC VIEW OF THE CITY OF MARYSVILLE, CAL.

Although an abundance of most excellent water lies within twenty feet or so of the surface of the ground, it has not been the custom to irrigate these peach lands until within the last two or three years, but now irrigating pumps driven by electric power have become regarded as an indispensable adjunct to every orchard. These plants are of various sizes, twenty horsepower units being about the average, and as the lift is but slight the belt-driven centrifugal pumps used throw ample water to irrigate large areas. These plants are in operation all but continuously from May to November, inclusive, which period covers the dry season, and the universal practice is to locate the well and plant on the highest piece of ground in the orchard in order that the water therefrom may flow through little ditches by gravity to every part of the orchard. To the eye the country appears to be perfectly level, yet upon closer examination it will be found to be slightly rolling, so that in an orchard of 100 acres a "head" of two feet or so may thus be given to these little irrigating ditches. At the rate which prevails for electric power for pumping purposes in the Marysville district, the costs of labor and power for irrigation varies from $2 to $2.50 per acre according to the character of the soil and the depth of the well, and as to the increase of efficiency which results from irrigation, instances are numerous wherein the production has been increased by 75 per cent., and it is perfectly safe to say that the rate of increased production is never below 40 per cent., while some growers claim that it is as high as 80 per cent. A peculiarity of the situation is that irrigation affects only the quantity of the output, for the quality of the irrigated and of the non-irrigated fruit is indistinguishable.

Electric power is used in and about Marysville for many purposes other than pumping—in fact, it is used almost exclusively in the power consuming industries thereabouts. The largest individual user of electric power is the Sperry Flour Company, for its 600-barrel mills require in their operation about 250 horsepower. Next in order in size of installation is the Marysville Woolen Mills, which consume close to 200 horsepower and two views of the interior of which are here presented. Then follows the Marysville Ice and Cold Storage Company with about 125 horsepower, the city waterworks with seventy-five horsepower, besides the brewery with fifty horsepower and numerous other installations for driving planing mills, printing presses, machine shops, dental motors, grinders, electric pianos and fan motors, of which latter above 160 are in use during the summer. Two-phase, 220-volt or 440-volt induction motors are used in all the larger installations and the smaller motors are of the single-phase induction variety. Moreover all motors above twenty-five horsepower in size are operated under contract with the California Central Gas and Electric Company, while those in smaller denominations are operated by the Marysville Gas and Electric Company.

Mr. D. E. Knight, in addition to being the founder of the gas and electric industry in Marysville, was one of the earliest California pioneers who came to the State in the first rush of gold seekers back in '49. Mining *per se* was not exactly suited to his fancy, for he did not remain in it long, as he saw better opportunities elsewhere. Soon after his advent, therefore, he began steamboating, with the result that eventually he established a line of river steamers which for years plied the waters of the bays and rivers between San Francisco, Stockton, Sacramento and Marysville, and further on up to the head of navigation. Prior to the building of the railroad, Mr. Knight was one of the most influential men engaged in the transportation business in California, and his boats were familiar objects on all the inland water courses, indeed, one of the principal towns of Yolo County—Knight's Landing—has given geographical perpetuation to his name. But his home and his interests always remained in Marysville, where he became

its most prominent and progressive citizen, and where he died, on January 4, 1900, in the seventy-fifth year of his age.

THE MARYSVILLE GAS WORKS.

Marysville possesses the distinction of being the second city on the Pacific Coast to build and maintain a plant for the manufacture of gas—San Francisco being the first, with the San Francisco Gas Company, which started its works on February 11, 1854, and Portland, Or., being the third, with the Portland Gas Light Company, 1858, which started its works in June, 1860. It was in May,

THE MARYSVILLE WOOLEN MILLS, OF MARYSVILLE, CAL.

that the Marysville Coal Gas Company was organized with a capital stock of $50,000, its principal officials being Messrs. Charles H. Simkins, president; A. Pierce, vice-president, and D. E. Knight, secretary, treasurer and superintendent. From the outset the work of installing the plant was prosecuted with unrelenting vigor, but the literal infancy of the business, coupled with lack of facilities—not to say lack of knowledge—made the task an arduous one, so that it was not until August 18, 1858, that gas was turned into the mains. Those were days in which heroic expedients were, perforce, resorted to; when bored out redwood and pine logs were used for street mains, and when, in the absence of coal, any other combustible which might be available was used. "In Marysville," stated T. R. Parker, president, before the Pacific Coast Gas Association,"* we used the castor bean for gas making for quite a time, and the product therefrom was quite a beautiful gas which needed very little purification, but the residuals amounted to nothing. So far as my experience goes, the woods of California are not sufficiently charged with carbon in the shape of resin and its kindred substances, to warrant transportation to points where they could be used for gas-making. Seeds have been found to be more useful, but the trouble is that the residuals from seed amount to nothing." Another early pioneer in the gas business of the Pacific Coast—F. H. Eichbaum—thus relates† an experience with making gas from pitch pine, which is no novelty in California or Nevada, and which was, in fact, used in Marysville for a time. "In this process," states Mr. Eichbaum, "the retorts used were the common cast-iron ones similar in

* Proceedings Pacific Coast Gas Association (1893–1897), Fifth Annual Meeting, page 297.

† *Ibid.*, page 295.

shape, but smaller and shorter, than those used in coal-gas making. The retorts were filled with wood and the charges were of fat pine, retorted until all the gas was driven off and the product stored in a holder, after being washed to free it from the tar, which was afterwards used principally as fuel. The fat pine used was almost resin, and it was so rich that the process was simply making resin gas from fat pine. The charcoal was of fair quality and helped out the fuel materially. The gas was good, and if such fat pine were obtainable now as then, many boxes, and all connections about the works outside of the retort house made by some local tinsmiths from galvanized sheet iron. Boghead, Lesmahago and Ince were the familiar names of the coals then used, while from 8000 to 9000 cubic feet of gas was considered a good yield from these gilt-edged coals. We then charged 150 pounds to a retort, three in a bed. By-products, with the exception of coke, were considered of no value in those days and were allowed to go to waste. Gas sold from $7 to $10 per 1000 feet.* Wool waste, castor beans and pitch-

THIS FIVE SET WOOLEN MILL IS DRIVEN THROUGHOUT BY ELECTRICALLY-TRANSMITTED POWER

works now making coal gas would be using this means today."

To quote Mr. Parker again,* for his earliest experience in gas-making in California was in Marysville, in view of which his reminiscences concerning the earliest days of the industry on the Coast really relate part of the history of gas-making in the city named: "Those of us who were in the gas business of the Pacific Coast in the early sixties, for instance, know with what crude and primitive apparatus we had to work—iron retorts, no exhausters, barrels for condensers and scrubbers, wooden purifying pine were auxiliaries. With no local competitor in the form of a corporation to contend with for commercial or municipal favor, with electric lighting looked upon as a scientific novelty, or, like a comet, to appear and disappear, frightening timid stockholders and tending to concentrate depreciated stock into a few hands, water gas was pooh-poohed at and its advocates handled unmercifully and without gloves at gas association meetings. Its candle power fluctuated; the gas stratified in the mains; it was destructive to meters, and the air was blue with talk of carbonic oxide or carbon monoxide forming a

*Proceedings of Pacific Coast Gas Association (1893-1897), Fifth Annual Meeting, page 48.

*In Marysville the rate at which it first sold was $12 per thousand —THE EDITOR.

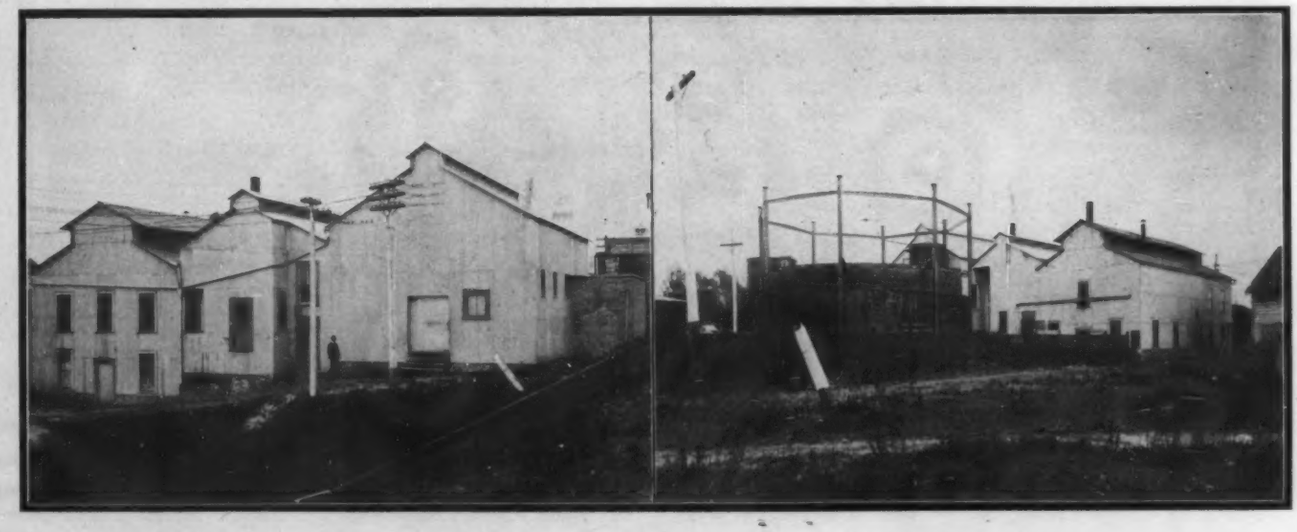
carbonic dioxide. Water-gas was in fact a most decidedly dangerous gas that required special legislation to restrict."

These excerpts from most authoritative sources tend to show the difficulties which surrounded the inauguration of the gas-making industry in the city of Marysville, as well as some of the ideas of its originators. The plant was started, as stated, as a coal-gas plant and so it remained until the spring of 1896, when, after having passed into other ownership than the original corporation, it was supplanted by a modern water-gas system, which, in turn, has now given way to a crude-oil system. But to revert to the original plant, the average candle power of the gas then produced was twenty-one, and its largest daily output was 12,000 cubic feet, with a monthly average of 200,000 cubic feet, while a total of sixty-eight consumers were served from its mains, which aggregated a length of three-quarters of a mile. In 1861 the length of main had increased to 14,500 feet. As to the price of coal, originally Wigand cannel cost $24 per long ton laid down in Marysville; anthracite from Sydney cost $25 per ton; a coal brought from Chile cost $15 per ton. and Lesmahago cost $22 per ton. Nevertheless the price of gas was reduced to $11 per thousand in 1851, and in 1863 it was still further reduced to $10. The gas works of this original plant consisted of two benches of fours, with a single sheet-iron holder measuring forty feet in diameter by sixteen feet in height, and containing approximately 20,000 cubic feet. In 1879 the business of the company had increased to a yearly output of 12,300,000 cubic feet, which necessitated extensions that warranted the increase of the capital stock of the company from $50,000 to $100,000. This was done in the year named. Mr. Knight was elected president and from that time on until his death he was paramount in the administration of the company's affairs.

Active competition sprung up, however, in 1898, first in the electric lighting business, as is discussed elsewhere, and then in the gas business, this latter occurring first from the Yuba Electric Power Company and afterward resulting in the organization of the Marysville Gas and Electric Company, which was incorporated in November, 1895, and which eventually absorbed the entire plant, property and good will of the Marysville Coal Gas Company. Since March 1, 1899, the Marysville Gas and Electric Company has been the sole distributor of gas and electricity for all classes of service.

One of the first features of the history of the gas business of Marysville which will interest the gas works manager rests in the extraordinary increase which occurred in the consumption of gas for fuel purposes after the consolidation of the original companies. In 1896 there were but six appliances in Marysville using gas as fuel; in 1899 there were 140 such appliance, and in the spring of 1902 there were over 300 gas stoves in use alone, while 70 per cent. of the output of the works was consumed for fuel purposes. Since then the use of gas appliances has been undergoing constant increase, so that now their number approximates 400 and probably 80 per cent. of the output of the works is in fuel gas. A more striking instance in illustration of the possibilities of developing the consumption of fuel gas, as well as in exemplifying the wisdom of pursuing a policy of liberality toward the public along every reasonable line, cannot be cited in all the country. True, Marysville possesses almost every climatic advantage in favor of the use of fuel gas, but the success attained has been due to favorable rates and hard missionary work in the way of education and solicitation rather than to climatic advantages. Aside from usual household uses gas is consumed in practically all the laundry, candy cooking, soldering, can making and cannery industries in and about Marysville, and it has done this to the displacement, after competitive test, of every other available heating medium from which gaseous fuel can be made.

When the Yuba Electric Power Company entered the gas business of Marysville it gave the contract for the installation of its gas works to the Western Gas Construction Company of Fort Wayne, Ind., which built one of its well known types of water-gas plants in a single set having a capacity of 3,000 cubic feet. This plant was finished on the first day of October, 1898, and was superseded, on September 1, 1899, by the present crude



THE GAS WORKS OF THE MARYSVILLE GAS AND ELECTRIC COMPANY

oil system, which will be the subject of description in a later issue of THE JOURNAL.

Active competition with the Marysville Coal Gas Company compelled the Yuba Electric Power Company to parallel the mains of its rival, and after the consolidation which resulted in the organization of the Marysville Gas and Electric Company had been effected, the work of uniting these two one-time rival mains into a single system was begun. Then followed an era of excavation of relics of gas antiquities in the way of gas mains of every variety of material from wood to cast iron, and of every size from one-quarter inch to eight inches. Then in the shortest line was always found the best way to reach consumers, so the Marysville pioneers of the gas business evidently reasoned, for the pipes were not laid in the streets alone, but instead were run across lots, on private property, at any angle and in any way to reach the customer.

The first work that was done toward the establishment of artificial lighting in Marysville is detailed above relative to the gas works, which was completed in 1858, but it was not until the winter of 1886-87 that the subject of installing an electric lighting plant came up for serious attention. Mr. Knight was then a power in Marysville, and his financial interests were wide spread. His interest in the electric lighting industry was, however, confined to a considerable block of stock which he held in the California Electric Light Company, of San Francisco, of which company he was a member of the board of directors during the winter named. Like all gas men of the period, Mr. Knight regarded electric lighting as the natural enemy of gas, and it was not until F. G. Waterhouse, since prominent in electrical circles in San Francisco, determined to establish an arc lighting plant in Marysville, using the system invented by his brother—the Waterhouse arc system, using third-brush regulation—that Mr. Knight determined to establish an electric lighting plant in the town. Mr. Knight then came to San Francisco and discussed the situation with Geo. H. Roe, then president of the California Electric Light Company, with the result that an order was given for the installation of a No. 7, Brush, twenty-five-light arc machine, which was set up in the spring of 1887 by James R. Petrie, now chief electrician of the power plant of the Mare Island Navy Yard, acting as installing engineer for the California Electric Light Company. This dynamo was driven through countershafting by a simple engine, rated at seventy-five horsepower, and steam for the operation of the engine was furnished from an old steamboat boiler that was set up out in the open air in the back yard of the frame shed which housed the engine and dynamo. The contract for street lighting was secured from the board of city trustees, and service was entered thereunder by the mast system, which rendered Mr. Waterhouse's plans practically futile; but nevertheless he had made considerable progress toward the installation of his system, in view of which he sold out to Mr. Knight on February 3, 1887, and the Waterhouse plant was never finished.

Two years later the second opposition appeared, this time in the person of one E. E. Parsons, who afterward earned unenviable notoriety through alleged fraudulent practices in electrical schemes, the opposition this time occurring through the installation of a Thomson-Houston 650-light alternator which Parsons and his associates erected "on wind." This plant was sold through the agency of the Thomson-Houston Electric Company, then held by S. H. Taylor, at that time prominent in electrical circles throughout the West, and now manager of the well known Electric Railway and Manufacturers' Supply Company, of San Francisco. But Parsons' paper and that of his company proved worthless, and the plant lasted but four or five months, when its ownership was transferred to the Marysville Electric Light Company, of which Mr. Knight was the leading spirit. But prior to this Mr. Knight had resolved to pursue the same tactics in dealing with Parsons which he had formerly resorted to in combatting competition, namely, to fight, in accordance with which he purchased from the California Electric Light Company a 600-light, Brush, 2000-volt alternator of the stationary disc armature type, together with an equipment of Brush transformers, all of which was installed under the supervision of F. E. Smith,* then chief electrician of the California Electric Light Company, in 1890. This alternator was driven by a simple Ohmen engine, rated at seventy-five horsepower, but the old steamboat boiler, which was built like that of a threshing engine, still did duty in making steam. About this time another Brush No. 7 arc dynamo was installed, and then, after the Parsons' plant had died a natural death, it was bought in by Mr. Knight, as stated, and the plants were united. Later two 1000-light Thomson-Houston alternators were added, to drive which, through countershafting, a Corliss engine, built by the Fulton Iron Works, of San Francisco, was installed, and this equipment, together with a General Electric alternator, which was also added some years later, constituted the plant of the Marysville Electric Light Company until its consolidation with the Yuba Electric Power Company, in 1898, and the formation of the present Marysville Gas and Electric Company.

It was on March 21, 1898, just one hundred and twenty-five days after the beginning of the work of its installation, that the Brown's Valley power house of the Yuba Power Company was placed in operation, and from it power was transmitted to Marysville, a distance of twenty-two miles, for the operation of the system that was destined to become paramount in the lighting and power industries of Marysville. This transmission system has already been described in these columns,† hence suffice it to say that it consisted originally of three two-phase "S.K.C." generators, driven by Pelton water wheels, for delivering 1080 kilowatts to line at 16,700 volts and 8000 alternations. These generators, and the plant, with some inconsequential rearrangements, are now part of the generating sys-

*Mr. Smith's biography appears in Volume XI, page 232, of THE JOURNAL, September, 1901.

†THE JOURNAL, Volume V, page 145, May, 1898; also Volume XI, page 147, July, 1901.

tem of the Bay Counties Power Company, whence the Marysville Gas and Electric Company now derives its electricity supply. The development of the business of the Yuba plant was very rapid, and as its volume increased it outgrew the ability of the Yuba Power Company to handle it, with the result that the Yuba Electric Power Company was organized in 1899. The latter company at once absorbed the business and properties of the Yuba Power Company, and it was, in turn, absorbed by the Bay Counties Power Company in the summer of 1900. In a sense, then, the Yuba-Marysville transmission was the forerunner of the Bay Counties Power Company, although the installation of the Nevada County Power Company, which is also an integral part of the Bay Counties system, antedates that of the Yuba plant by almost three years.*

At present the substation of the Marysville Gas and Electric Company is substantially the same as when installed by the Yuba Power Company in 1898, with the exception that the lowering transformers, which originally occupied a portion of the space of the main room of the building, are contained in a brick fire-proof vault adjoining the substation, as appears to the left of the illustration on page 129. Within this building, which is the substation, there is a simple switchboard of the Stanley type, with panels for the power and lighting circuits, as well as for the arc circuits, which, as stated in the following paragraphs, are of the constant current, alternating type. The usual Stanley lightning arrester and high tension switching apparatus is provided, and this, together with an electrically driven centrifugal pump for providing water for cooling the transformers, practically completes the inventory of apparatus contained within the station.

The incandescent circuits leading from the substation are of the two-phase, 2200-volt variety, with pole transformers, feeding 110 volts into Edison three-wire, single-phase, distributions throughout the business section, while residence lighting is rendered by generally separate single-phase transformers. Power service is rendered by the two-phase system at either 1200 or 500 volts.

*THE JOURNAL, Volume I, page 107, November, 1895.

THE ARC LIGHTING SYSTEM.

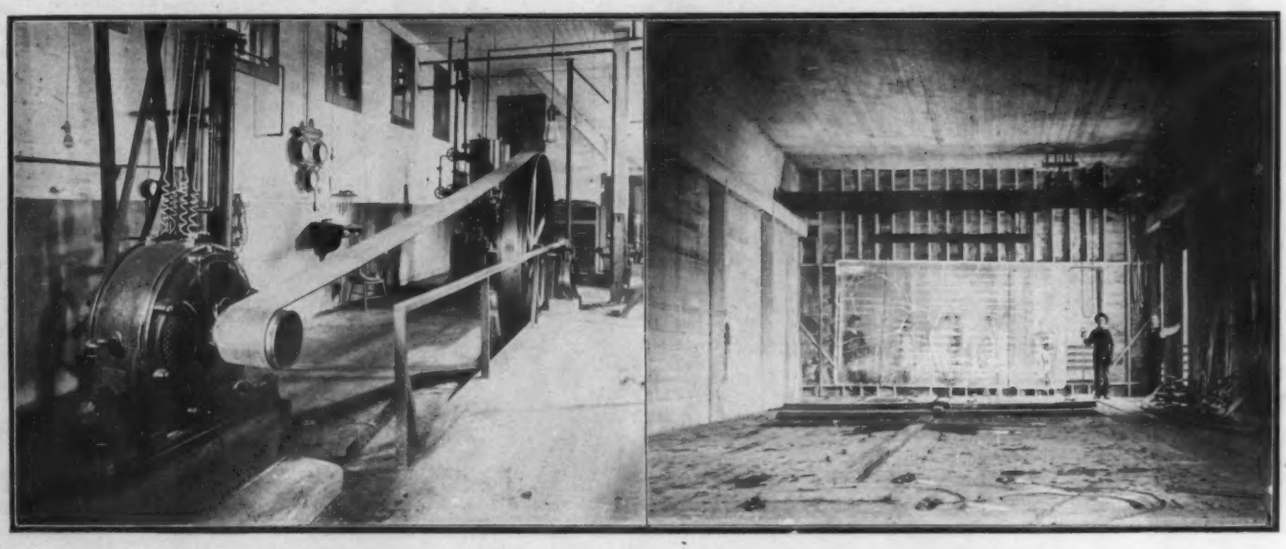
The Marysville Gas and Electric Company was the second local company taking power from the transmission circuits of the Bay Counties Power Company to adopt the alternating current series inclosed arc lighting system for street lighting purposes, and this original installation has been copied in practically all cities and towns which are upon the transmission circuits of the California Central Gas and Electric Company. It is fitting, therefore, that the system should be described in detail in this article in order that the necessity for further description in the articles which follow may be obviated.

In Marysville the system of street lighting consists of two 6.6-ampere constant current transformers of the type described, each having a capacity of twenty-five lamps. The distribution of the lighting and power polyphase current throughout the town is of the two-phase variety, to conform with which these two arc lighting transformers are placed in the respective phases of the system, the applied potential being 2200 volts. The automaticity of the arc lighting system closely approaches the ideal, for, beyond starting and stopping the street lights, the station apparatus requires virtually no care and the lamps are trimmed but twice a week.

THE ICE AND COLD STORAGE PLANT.

Aside from its flour mills, the most important manufacturing industry in Marysville is the plant of the Marysville Ice and Cold Storage Company, which started in business on April 1, 1900, and which occupies one-half a block on Ninth Street, between A and B streets.

This ice plant is interesting because of its comparative originality, for it is largely the development of Mr. Paul Heilman, president of the company named, to whom the writer is indebted for much interesting information concerning it. Though but a small plant (it has a capa-



ELECTRIC POWER IN THE PLANT OF THE MARYSVILLE ICE AND COLD STORAGE COMPANY.

city of fifteen tons daily, together with a cold storage capacity of 20,000 cubic feet), its principles of operation are such that they at once appeal to the reason of any one as being the nearest possible approach to Nature's method of ice-making. As is well known, the water of rapidly flowing mountain streams is the best and purest, and at the same time that the freezing of water tends to its purification, in consequence of which water in motion, when slowly frozen, should make better ice than water which is quiescent. As an example, it is well known among ice makers that in making ice under the can or tank system, wherein a tank of water is gradually frozen inwardly from the sides of the tank to the center, such impurities as may be in the water are forced toward the center of the tank as freezing progresses until, when the block is finally frozen solid, the very center of the cake is often highly discolored from impurities that have been concentrated there. More than this, upon breaking open the ice block it is not unusual for the odor of this discolored portion to be almost nauseating, while the portions of the ice on the outer surfaces of the block will be far more pure and wholesome. The reason for this is obvious, for, as stated, since freezing is a purifying process, such impurities as are in a tank of water that is to be frozen by the tank or can process must be driven to the center of the tank as the formation of ice advances.

If, on the other hand, the water from which ice is to be made is conveyed between parallel plates so as to be constantly replenished with fresh water that is in constant and fairly rapid agitation, then no opportunity is afforded for the concentration of impurities within the ice, for the reason that in this particular process only pure water congeals, while such impurities as may be in the water from which the ice is made are swept on and away from the ice block by the movement of the water. This is the principle underlying the plant of the Marysville Ice and Cold Storage Company, and it is the principle known to refrigerating engineers as the direct expansion plate system, which produces ice of an entirely different texture and grain from that of the can system which is in far more general use. Plate ice is superior to can ice in another important regard namely, in that it is more hardy and can stand shipment anywhere within the State without serious shrinkage.

The manner in which ice made according to the plate system is turned out is suggested in an admirable way in the engraving appearing on page 131. In the Marysville plant there are eight ice-making compartments, each of which measures in the clear sixteen feet by eight and one-half feet by twelve inches, thus turning out blocks of ice of the dimensions given, and each of which weighs between three and four tons. Between these compartments, which are of sheet steel, are the usual refrigerating pipes, which are run as radiator piping, as is customary in all processes of ammonia refrigeration, and these pipes reduce the temperature of the steel plates to the degree necessary to slowly freeze the water running by the plates. In fact it requires six days to freeze a block of ice of the dimensions given, and the process is continuous, not only in that it is in operation at all times, but also in that it produces four blocks of ice each day—one compartment of the eight being always idle.

Electric power is used exclusively in this plant, all service being rendered through induction motors of the two-phase variety. The two compressors, which are duplicate sets, are respectively driven in the manner shown in the illustration by a fifty-horsepower "Type C" induction motor of Westinghouse manufacture, but the most interesting application of power about the plant consists in the use of a General Electric induction motor which operates the crane for lifting a block of ice from its compartment and carrying it to the platform where it is sawed into smaller blocks of merchantable sizes. This motor is of the ten-horsepower, two-phase, 220-volt type, so fitted with collector rings and brushes that a variable resistance may be cut into its rotor windings. Its functions are those of hoisting and taking care of the travel of the crane, which is done through a controller shown in the rear of the tank room on the wall to the right of the ice block appearing in the illustration on the preceding page.

POWER FROM THE EARTH'S HEAT.*

BY WILLIAM HALLOCK.

IF we consider the amount of energy brought to the surface in the form of hot water from all the hot springs, we should certainly reach very large figures, and this energy, although not available for operating an ordinary steam engine, might be utilized perfectly well for operating an engine which used some liquid like ether, alcohol or carbonic gas, boiling at a temperature considerably below the temperature of the water in the hot springs.

The suggestion for utilizing the heat below the surface of the earth has been a favorite one, and has reappeared at every recurrence of interest in underground temperatures.

It is comparatively easy to compute the depth to which it would be necessary to penetrate in order to find temperatures that would be suitable for the operations with the ordinary steam engine; but in some localities the depth would be so considerable as to appear prohibitory, for the present at least. Still, nothing seems to be impossible to modern engineering, and perhaps the next ten years will make a hole 15,000 feet deep as simple a matter as one of 5000 feet is at the present time. Moreover, we are not compelled to select such disadvantageous localities for our enterprise. If, for example, we choose, a place where the remnants of volcanic energy are near the surface, it would, undoubtedly, be possible at the present time to put down a hole deep enough to reach a temperature of 300 degrees.

The problem, it appears to the writer, is not so much concerned with the putting down of a hole, or holes, as with the continued and sufficient supply of energy from the rocks beneath, because the moment operations are commenced, and water or any other liquid is introduced into the bottom of the well, the surrounding rocks will immediately be cooled, and must rely upon the outlying areas for a supply of heat by conduction. Thus it would be necessary to start our experiments at a depth where the temperature was perhaps 500 or 600 degrees in order that we might ultimately obtain a working temperature of 300. These conditions would depend entirely upon the size of the reservoir that we could obtain and upon the heat conductivity of the rock.

Three lines of development are open in attempting to practically utilize the earth's heat. In the one case a liquid with a low boiling point may be used in holes of comparatively slight depth; or water may be employed in special localities near volcanoes or hot springs; or, again, the hot water may be used for heating purposes alone.

* Abstract from *Cassier's Magazine*, Volume XXII, page 566, February, 1903.

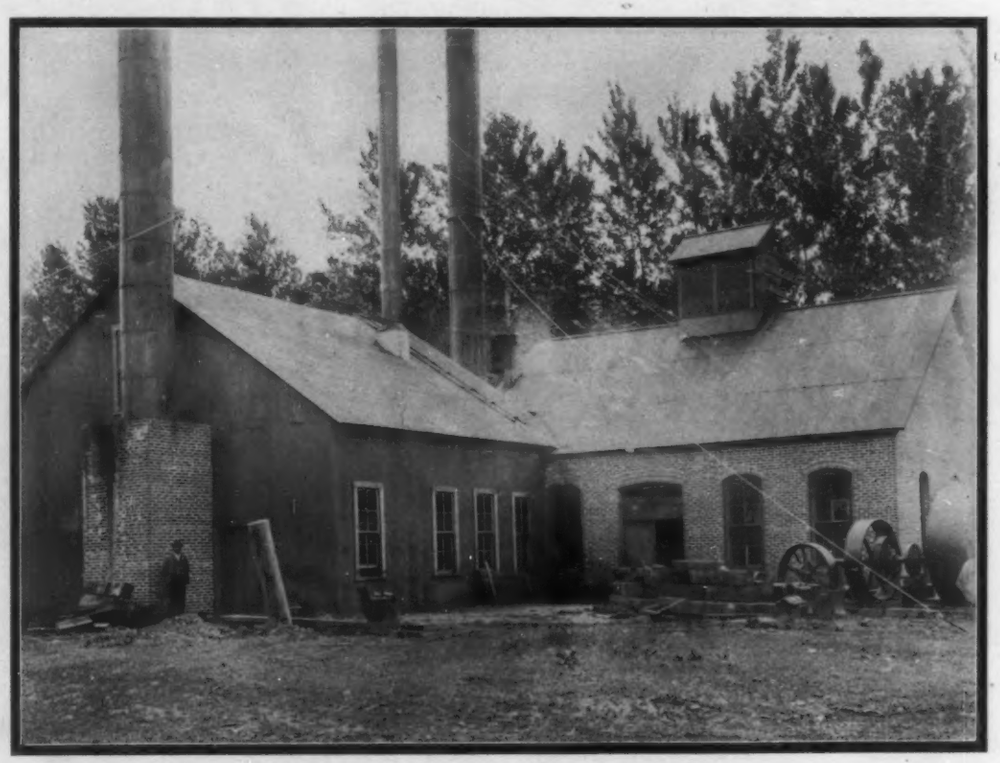
THE WALLA WALLA GAS AND ELECTRIC SYSTEM.

WHILE the Westinghouse Electric and Manufacturing Company was endeavoring to solve the problem of electric power transmission by the use of single-phase apparatus at the mine of the Standard Consolidated Mining Company* at Bodie, Cal., the General Electric Company was performing equally interesting experiments along similar lines, though under less spectacular surroundings, in the plant of the Walla Walla Gas and Electric Company in Walla Walla, Wash. Mention of this pioneer single-phase transmission was made in these columns long since;† but before proceeding to a description of the present installation, it is well to briefly review the early history of the system, for it has an important bearing on the original development of electric power transmission on the Pacific Coast.

In 1892 the Walla Walla Gas and Electric Company felt it to be imperative that the water power of Mill Creek, which was located some five miles east of the city of Walla Walla, should be utilized for the operation of its electric light and power plant, and after considerable negotiation a contract was awarded for the installation of the plant to be described. The water for the operation of the plant was brought to the station through a wood-stave pipe forty-eight inches in diameter and having a total length of 5600 feet, the static head being seventy-three feet while the effective head was sixty-six feet. The pipe line terminated in a sheet-iron Y pipe supplying a double-nozzle Pelton water wheel, which was seventy-seven inches in diameter and capable of developing 175 horsepower at a speed of 100 revolutions per minute, the shaft of which was provided with an eight-foot pulley, from which was driven by rope drive a jack-shaft that, in turn, belted back to the pulley of a 100-kilowatt, single-phase generator having a frequency of 8000 alternations per minute. This machine was of the familiar "A 100" type, as built by the Thomson-Houston Electric Company at the time it was merged into the General Electric Company. It was composite wound and, together with a fifteen-kilowatt, 100-volt, Thomson-Houston exciter and the accompanying switchboard, constituted the electrical equipment of the station, although the original plans called for double the capacity given. The generator delivered 2000 volts to line direct when in regular transmission service, but it should be borne in mind that during the period of starting, the 500-volt exciter was used as a starting generator, as its potential was thrown to line and used to drive a 7½-kilowatt direct-current motor in the substation at Walla Walla, by means of which the synchronous motor was brought up to speed.

But to return to the details of the apparatus used: The line consisted of a single circuit of No. 0, B. & S. gage copper, which led direct from the generating station to the city substation. The receiving plant at the latter point consisted of an "A 100," 2000-volt, T.-H., single-phase, 2000-volt generator used as a synchronous motor (the machine being a counterpart of that in the power house), together with one 7½-kilowatt, direct-current, bipolar starting motor referred to, and a small 110-volt exciter having a capacity of 1½ kilowatts and used for exciting the fields of the "A 100" synchronous motor. The line terminated at each end in the levers of double-pole, double-throw switches so coupled that at the generating station the line might be thrown upon either the 500-volt direct-current generator, or the 2000-volt alternator, so that at the receiving station the line could be thrown upon either the direct-current bipolar starting motor or the 2000-volt synchronous motor.

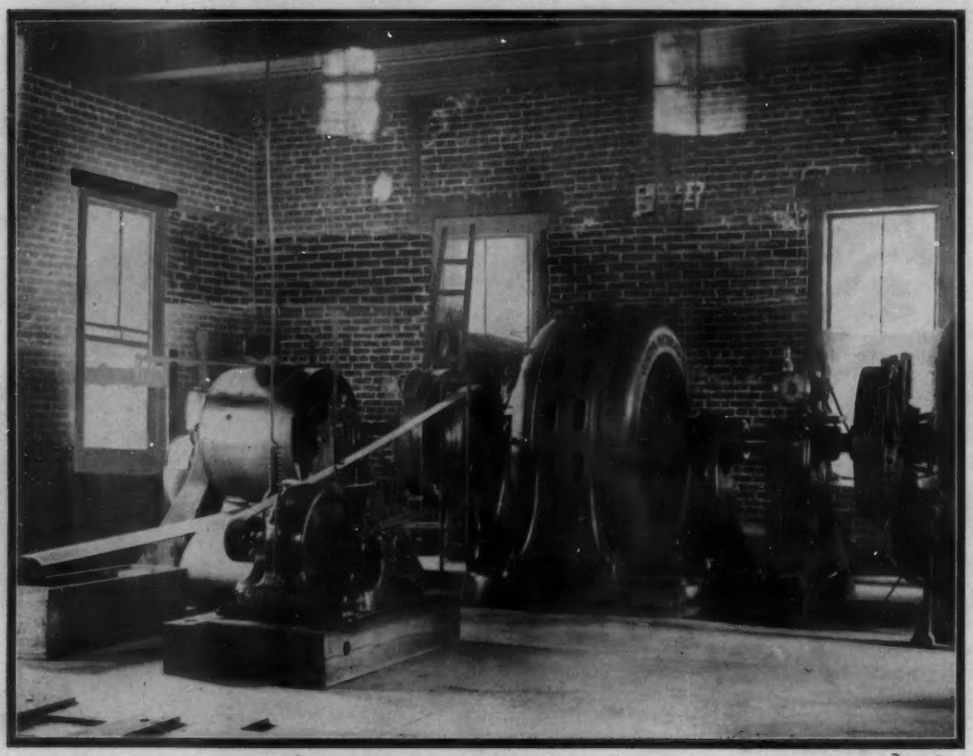
The method by which the plant was put in operation is perhaps obvious, but it is nevertheless interesting. First the generating plant, *i. e.*, both machines, was brought up to speed and the rheostat in the fields of the 500-volt generator was cut out for maximum voltage, the fields of the alternator being excited therefrom, no atten-



SUBSTATION AND STEAM AUXILIARY PLANT AT WALLA WALLA

*Described in *Cassier's Magazine* for March, 1895.

†THE JOURNAL, Volume I, page 36, August, 1895.



A CORNER IN THE WALLA WALLA PLANT

tion being paid to its voltage. The double-pole, double-throw switch was then thrown down upon the clips forming the poles of the 500-volt dynamo, which threw its direct-current potential on the line. In the mean time the attendant at the generating station had telephoned the substation that he had started up the plant, whereupon the latter threw the line current (direct current) upon the 7½-kilowatt starting motor by bringing down the double-pole double-throw switch upon its terminals. This motor brought the alternator up to speed, and at the same time it speeded the little exciter up to voltage, the latter being connected to a pilot lamp to avoid error. In the mean time the synchronous motor had been running idly in dead fields, but when these various maneuvers had been gone through with the attendant at the receiving station telephoned to the power house that all was ready and that he was to stand by the main switch, whereupon the motor attendant would open the main switch and quickly throw in the station transformer operating the pilot lamp and voltmeter through a separate primary switch. This done he would wait for the appearance of the 2000-volt alternating current before closing the main switch that would throw the synchronous motor on to the line.

While this had been going on at the substation the attendant at the power house, in compliance with his instructions, had been standing by the main switch, and when he noticed that the direct-current load had gone off he would quickly throw the main switch from the 500-volt contact. Thereupon the man at the motor station, who had been watching the pilot lamp on the station transformer, would throw the line upon the synchronous motor with one hand as soon as the lamp came up to candle power, and would immediately close the field circuit of the alternator with the other hand. The motor would soon swing into step without the use of a synchronizing device. Then the starting motor would be shut down by throwing the clutch on the pulley of its countershaft and the power transmission was ready for business.

This plant was installed in the spring of 1893 and was used in conjunction with the steam plant which the company built in 1890, wherein tubular boilers burning wood gave steam for the operation of a 100-horsepower Ball tandem compound engine, from which were driven, through countershafting, the arc and incandescent circuits of the city. Upon the completion of the transmission system additional power was delivered to the countershaft from the synchronous motor, in addition to which the incandescent lighting load was carried by the transmission line, the steam plant being used mainly as a reserve. This was very necessary in view of the fact that, although Mill Creek rises in the State of Washington not far from the Oregon line, where it drains an area of many square miles in a region of heavy precipitation, its watershed is so denuded of trees and vegetation that the creek is subject to rapid fluctuations and cannot be relied upon at brief times as a source of water power. The average flow of the stream during the extreme dry season is 2800 cubic feet per second, but during the winter months the flow is much greater. Though it is now ten years since this substation was installed, it still remains typical of the modern steam-driven auxiliary to the water-power transmission system of today. It should be added that the interesting method resorted to for starting this now historic transmission was devised and installed by Mr. W. A. Burkholder, whose prominence in the electrical development of the Pacific Northwest is well known.

The transmission here described supplied practically all the current demanded until the year 1900, except that during the last three years of that time it was materially assisted by the steam plant, owing primarily to the rapid increase in the load. It was in September, however, of the year named, that the plant was closed down and everything was taken out or rebuilt except the pipe line, in order that a more complete and up-to-date plant might be installed. This was finished in May, 1901, and is

now in operation, its distinctive features being the employment of the monocyclic system in conjunction with a rotary steam engine as its auxiliary.

The point of diversion of water from Mill Creek is now, as it was before, about 5600 feet above the plant, and here a concrete dam has been built across the creek, raising the water a few feet above its natural bed. The wood-stave pipe line remains as originally installed, for after continued use for seven years it was found to be in practically perfect condition. That was three years ago, and today the stave pipe is apparently as sound as ever. It is buried throughout and its depreciation is certainly very light. With the exception of the pipe line, the water-power plant was rebuilt almost throughout. The power house is built over a brick and concrete arch that spans the tailrace, and in the plant McCormack turbines were substituted for the jet wheels formerly used, for the reason that the turbines permitted the use of draft tubes, which could not be adapted for use in conjunction with wheels of the Pelton type. In consequence of this change the tailrace was lowered fourteen feet, draft tubes measuring seventeen feet six inches in length were installed, and, with the increase in head accomplished at the dam, the effective head was raised to ninety feet. These draft tubes give a vacuum of twenty inches.

The power house is of brick, forty feet square, with a truss roof and a concrete floor. The hydraulic plant consists of one 27-inch McCormack turbine built by the S. Morgan Smith Company of York, Pa., and rated to deliver 450 horsepower under the head given. The wheel is direct-connected to a 300-kilowatt, General Electric, revolving-field dynamo delivering monocyclic current at 6600 volts and 60 cycles. Exciter current is taken from a 7½-kilowatt, multipolar machine which is belt-driven from the main shaft. In this station a 400-horsepower rotary engine of the Thomas & Brumagin type is installed. This engine, which is the first of its kind to be put on the market, runs at 200 revolutions per minute, and is belted to the generator shaft, which is provided with a Hill clutch, so that the generator can be run by water or steam, or both, as necessity may require.

Beyond stringing an additional wire, but little if any change was made in the pole line running from the power plant to the Walla Walla substation. The poles are of Washington cedar, thirty-five feet long with eight-inch tops, and although designed to carry two circuits of three wires each, but one circuit has thus far been run, and this consists of one No. 8 B. & S. gage hard-drawn copper wire in addition to the two No. 0 wires originally run. The poles are spaced 100 feet.

In the Walla Walla substation the step-down transformers reduce the line potential to 2080 volts for local distribution in incandescent lighting and constant potential arc service, these reducing transformers consisting of two 100-kilowatt single-phase and two 50-kilowatt "teaser" transformers which are connected by means of a cross connection on both primary and secondary sides so as to lower from 6600 to 2080 volts. In addition, two constant current transformers, of 75-light and 25-light capacity respectively, carry 100 "7½ A" series inclosed arc lamps on the Hartford system. All local incandescent distribution is by separate transformers at 110 volts through both the two- and three-wire systems in the residence and business sections respectively.

As to the monocyclic system, it may be stated that it was designed by the General Electric Company to meet the demand for alternating current service wherein the main load was in lighting, with the power load as incidental. The generator is essentially the same as that of a single-phase machine, with the exception that, in addition to the main coils, it contains a number of smaller coils, which furnish an electromotive force displaced as to phase, for the operation of motors through a third wire. This third wire thus tapped is known as the "teaser" circuit, which is not necessary for lighting, but must be carried wherever motors are installed. For

THE M'CORMICK TURBINES IN THE WALLA WALLA POWER HOUSE

lighting, the wiring, both on the primary and secondary sides, is identical with that for single-phase work. All lights are connected between the outside single-phase mains leading from the generator through the usual transformer connections, but to operate motors the third or "teaser" circuit of the generator must be present, the motors used being three-phase induction motors of the ordinary forms. The monocyclic system, therefore, possesses the flexibility of the three-phase system in so far as the use of transformers is concerned, with the added peculiarity that the bulk of the load, which must be in single-phase current, is thrown upon a single phase, so to speak, of the system. And this particular single phase, so to speak, may be identified unerringly because it exists between the two largest of the three wires forming the line circuit. Its main advantage over any polyphase system, therefore, rests in the fact that it employs only single-phase service for lighting, with extreme simplicity in wiring. There is no need of balancing the load between different circuits or phases when the monocyclic system is used, and there is neither possibility for unbalancing voltages nor reaction on the lights due to fluctuation of motor loads or starting currents. It is essentially a system designed for the operation of lighting load with power as an adjunct.

At the power house the switchboard is of blue Vermont marble, fitted with both potential and current transformers, together with current, voltage and exciting-current indicators, a three-phase electrostatic ground detector and oil switches for operating the high potential circuit. The fuses are of the spring expulsion type, while the line is protected from lightning by Wirt arresters inclosed in iron boxes and connected with ground wires. A good ground was secured by digging down in the earth to wet gravel and there bedding a coil of wire in powdered coke.

In addition to the transformers named the substation contains a skeleton switchboard upon which are mounted current and potential indicators for the incandescent lighting and power load of two circuits. The constant-current circuits are each provided with current transformers and ammeters, as well as tubular plug switches on both primary and secondary circuits. The substation is protected from lightning in the same manner as the power house and it also contains an oil switch for disconnecting the entire substation from the primary lines. The secondary lines are equally well protected. Since the installation of this larger plant was made the company has arranged to supplant the Ball engine, which was used as an auxiliary in the substation, by a 520-horsepower Russell four-valve engine. This engine is now en route to Walla Walla, and steam for its operation is to be supplied by a battery of four new boilers, three of which are already erected and the fourth of which will soon follow. This steam auxiliary will give an effectual safeguard against any possible shut-down from failure of the water power.

Gas for distribution in Walla Walla was first made by the company in 1881, when it was manufactured by a process combining the use of wood and oil. It had then about one mile of mains and two employes were required for its operation. Now nineteen-candlepower coal gas is produced, of which it makes and distributes close to 7,000,000 cubic feet per year, the prices which prevail being $2 per thousand for fuel gas and $3.50 per thousand for illuminating gas. Its works are contained in brick buildings, with iron roofs, which are models of convenience and cleanliness. The retort house measures twenty-six feet by twenty-nine feet in the clear and contains one bench of five-inch retorts and two benches of three-inch retorts; the purifying room is sixteen feet by twenty-nine feet in size and contains two purifying boxes four feet by eight feet in size, while the holder is thirteen feet by thirty-six feet in diameter and has a capacity of 13,000 cubic feet. In the rear is an open front coal house twenty-eight feet wide by 100 feet long, which differs from the other buildings in that it is of wood with an iron roof.

The gas works were first built by A. Pierce, of San Francisco, with whom was associated Charles Patterson as owner. Mr. Patterson was local manager of the company until 1885, when he sold out his interests to Mr. Pierce, and in the fall of the same year C. E. Burrows took possession for Mr. Pierce and later bought him out for the present owners. H. Wadsworth, of San Francisco, is president of the company, A. R. Burford is vice-president and C. E. Burrows is secretary and general manager. The plans for the electric plant were drawn by D. L. Huntington, C. E., general manager of the Washington Water Power Company of Spokane, Wash., while the construction was carried out under the supervision of E. C. Morrow, superintendent of the electric department.

DOES TRANSMISSION PAY?

DOUBT is often expressed in uninformed quarters as to whether electric power transmission, as conducted in California over long lines, at high voltages, and sometimes under disappointment as to the reliability of water powers, is really a paying business, particularly in view of the development of fuel oil of excellent quality in many fields within the State. Some pertinent evidence upon this point was given in New York recently* by Mr. George H. Barker, at one time president of the Edison Electric Company of Los Angeles, Cal., but who is no longer interested in electric power transmission work in any manner whatever. Mr. Barker's answer in response to the query propounded in the above caption is, therefore, from a disinterested source, in view of which it is the more valuable.

"The long-distance, high-voltage, electric power transmission companies of California can prove to you," he said, "that they can transmit power from water-power plants to the point of consumption and pay interest on the whole accompanying investment cheaper than they could generate it by steam power if fuel cost them absolutely nothing. While a water-power plant is an expensive thing to install, the labor and maintenance required per kilowatt-hour, if the plant is a large one, is a very small item compared to what it is in a steam plant. Water-power plants are now considered by investment houses as among the best classes of investment. The Edison Electric Company of Los Angeles, for instance, is having no trouble in disposing of bond issues up to 75 per cent. of the cost of its expensive improvements and its 5 per cent. bonds are selling at a premium."

Electrical World and Engineer, Volume XLI, page 198, January 31, 1903.

LIGHTNING INTERRUPTS NIAGARA SERVICE.

BY FRANK C. PERKINS.

THE most disastrous accident which has ever happened to the Niagara Falls Power Company's plant, interfering with the transmission of power to Buffalo and the surrounding towns, occurred Thursday evening, January 29th. An electric storm passed over western New York with heavy thunder and lightning, the temperature being high, and yet within a few hours a snow storm followed, with a corresponding lowering of the temperature. The lightning struck a local 2200-volt line of the Niagara Falls Power Plant, forming a short circuit in the cable bridge, through which are carried all the conductors connecting the 5000-horsepower generators in the power house with the static step-up transformers in the transformer house across the canal. The interiors of the cable bridge and the transformer house were instantly on fire, and all of the cables crossing the bridge were totally destroyed, shutting down the entire plant of from 50,000 to 75,000 horsepower. Undoubtedly the fierceness of the fire was aggravated by the great quantities of inflammable insulation which covered the cables, they being fifty-two in number, each of 1,000,000 circular mils in cross section.

The new power house has five 5000-horsepower generators in operation, but the temporary connections made with the transformer house were interfered with by the fire, which resulted in a complete closing down of the generators. In extinguishing the fire a large quantity of water was poured into the transformer house, completely deluging the static air-cooled transformers and making them useless, until they could be thoroughly dried out. Fortunately there was a stock of high-tension, lead-covered cable on hand, and this was immediately pressed into service, so that before morning thirty-six new cables were in place and a new roof was constructed for the transformer house and bridge, which enabled four 5000-horsepower alternators to be placed in operation. It will undoubtedly be some time before the entire plant is in perfect working order again, but most of the power users were supplied with current before Friday night.

The accompanying photographs show the interior of the bridge, with its new roof and cables, the next morning after the fire, with 20,000 horsepower being generated in the two power houses. It was, of course, a most serious matter for the users of the Niagara power, as many of them operate their plants day and night, and a shut-down of even a few hours is very disastrous. This was particularly so in reference to the electro-chemical plants using electric furnaces and also of factories where numerous men are employed. The power plant of the Niagara Falls Hydraulic and Manufacturing Company, which develops power from a surface canal through the city of Niagara Falls, was able to give great assistance during this trouble to local users. The damages accruing from which, it is stated, will probably exceed $50,000, and undoubtedly much more if the losses of the tenants and other power users are considered.

The street railway and lighting services of the city of Buffalo were greatly affected by the accident at the power plant, but the large storage batteries which had been installed carried the load for some time, although they were soon exhausted under the heavy discharge. The street railway storage battery, however, carried the load until the large reserve steam plant could be placed in operation, but the car service was badly crippled until the Niagara power was again ready for transmission, although the car lines were never entirely shut down.

The fifteen 5000-horsepower generators and all of the apparatus of both power houses No. 1 and No. 2 are in perfect condition, the reports to the contrary notwithstanding, and only a very small proportion of the static step-up transformers were damaged in any way by fire or water. The lightning did not strike the 22,000-volt lines, but the damage was confined to the 2200-volt cables connecting the transformer house and power house No. 1.

SAN FRANCISCO'S LIGHTING INDUSTRIES.

CONFORMING with the provisions of the city charter, the gas and electric companies rendering lighting and power service in the City and County of San Francisco have rendered their annual statements to the Board of Supervisors for the purpose of enabling the latter to fix the rates to be charged during the next fiscal year. These sworn statements contain much interesting information concerning the finances of the respective companies, in view of which they are presented in abstract, the figures, unless otherwise stated, being for the year ending December 31, 1902.

EQUITABLE GAS LIGHT COMPANY.

RECEIPTS.

Revenue from the sales of gas	$ 130,892 25	
Revenue from the sales of tar	2,791 65	
Total receipts		$ 133,683 90

DISBURSEMENTS.

Coal	$ 48,394 25	
Oil	25,661 26	
Water	1,109 55	
Expenses and repairs	2,408 44	
Labor	8,306 60	
Rents	6,000 00	
Salaries, stationery and sundries	18,553 19	
Meter repairs	1,413 81	
Insurance and taxes	2,305 48	
Total disbursements		$ 114,152 58
Net income		$ 19,531 32

The original cost of the plant was $405,172.88. There are outstanding 138,820 shares of a par value of $20.00 each. The company owes $34,648.75.

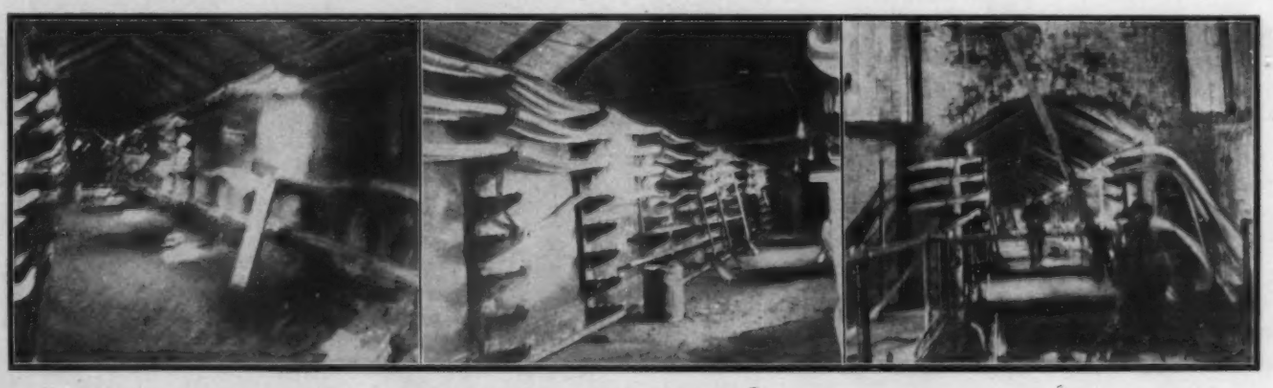
SAN FRANCISCO GAS AND ELECTRIC COMPANY.

RECEIPTS.

Sales of gas	$1,129,199 03	
Sales of electricity	801,353 78	
All other sources	59,281 78	
Total receipts		$1,989,834 59

DISBURSEMENTS.

Manufacture of gas	$ 925,468 45	
Manufacture of electricity	642,530 31	
Total disbursements		$1,567,998 76
Net income		$ 421,835 83



THE BURNING OF THE CABLE BRIDGE OF THE NIAGARA FALLS POWER COMPANY

The affidavit of the San Francisco Gas and Electric Company states that the present value of the plant is "impossible to estimate," but its present cost is valued as follows:

Gas plant	$6,580,861 81	
Gas mains and pipes	3,137,461 15	
Gas Meters	341,155 94	
Gas lamps	76,789 95	
Value of gas plant		$10,136,268 85
Electric plant	$3,437,160 59	
Conduits	810,483 59	
Meters	102,677 02	
Value of electric plant		$ 4,350,321 20
Total value of plant		$14,486,590 05

There is capital stock outstanding to the amount of $12,994,284.36; bonds outstanding to the amount of $623,000.00, and a floating debt of $370,691.75. No dividends were paid to shareholders during the year.

PACIFIC GAS IMPROVEMENT COMPANY.

RECEIPTS.

Receipts from all sources	$ 369,255 00	
Total receipts		$ 369,255 00

DISBURSEMENTS.

Oil and coal	$ 137,746 38	
Other supplies, manufacturing, labor and maintenance	75,168 77	
Salaries, interest and general expense	117,530 31	
Taxes	19,926 60	
Total disbursements		$ 350,372 06
Net income		$ 18,882 94

The cost of the property is given at $4,615,119.01. There are 35,000 shares of stock outstanding; the bonded indebtedness is $1,210,000 00, and on October 31, 1902, the floating indebtedness was $49,784.46.

INDEPENDENT ELECTRIC LIGHT AND POWER COMPANY.

RECEIPTS.

Sales of electricity	$ 470,884 54	
Interest accrued	2,355 27	
Total		$ 473,239 81

DISBURSEMENTS.

Cost of manufacture, distribution and general expense	$ 239,037 97	
Total		$ 239,037 97
Net profits		$ 234,201 84

In addition it is stated that the net earnings for 1901 were $76,575.12, to which should be added accrued interest to the amount of $188.01, making the total earnings for 1901 to be $76,763.13, or the sum of $310,964.97 for the years 1901 and 1902. Dividends to the amount of $220,000.00 were paid during 1902, to which should be added the amount written off for depreciation, viz., $57,846.57, giving a total of $277,846.57. The surplus on December 31, 1902, was, therefore, $33,118.40.

The present cost of plant is given as follows:

Lands, station and buildings	$ 259,510 65
Motive power	683,378 14
Arc lighting apparatus	55,666 10
Incandescent and power apparatus	623,583 42
Pole lines	100,418 03
Installations	98,674 34
Cables	408,246 48
Conduits	560,992 59
Total cost of plant	$2,790,469 75

There has been issued 29,000 shares of stock, fully paid up, making $2,900,000.00. There are no bonds issued or outstanding, and the floating debt is nominal, all purchases being discounted.

INDEPENDENT GAS AND POWER COMPANY.

DISBURSEMENTS.

Extension of mains	$ 402,232 11
New meters	52,252 23
New services	78,351 34
Works and improvements	433,831 64
Lands, stations and buildings	108,997 18
Total	$1,075,664 50

The company states that it is distributing gas to only a very limited area, covering a very small part of the projected distributing system, and that it cannot, under the ciscumstances, give any idea as to the cost of the product. It has issued 50,000 shares of stock of the par value of $5,000,000 00, and has no bonds nor floating debt.

MUTUAL ELECTRIC LIGHT COMPANY.

Receipts for 1902	$ 116,423 41
Disbursements	96,516 19
Net profits	$ 19,907 22

The original cost of the plant was $433,815.70. The present cost is impossible to determine. The capital stock is $500,000.00, of which there have been issued 41,000 shares at $10.00 each. There are no bonds outstanding, and the floating debt is $28,170.83.

MARTEL POWER COMPANY.

Receipts	$ 21,100 40
Disbursements	16,810 60
Net profits	$ 4,289 80

There was expended $47,500.00 in construction, the plant costing $50,000. Of its capital stock, 34,220 shares are outstanding, while its indebtedness is given as about $20,000.00.

CENTRAL LIGHT AND POWER COMPANY.

Receipts	$ 89,203 14
Disbursements	60,136 56
Net profits	$ 29,066 58

The sum of $40,801.31 was expended for construction. The plant cost originally $238,600.00, and 70,000 shares are outstanding. There are no bonds, and the floating debt amounts to about $10,000.00.

ARID LAND RECLAMATION IN CALIFORNIA.

ONE of the greatest opportunities for the reclamation of arid lands in California, and perhaps in the entire Southwest, has been found to lie in the utilization of the waters of the Colorado River on the adjacent lands in California and southern Arizona. As a result of an investigation along this river, made in January, 1902, by the hydrographic branch of the United States Geological Survey, the extent of the alluvial bottom land between Camp Mohave and Yuma was found to be from 400,000 to 500,000 acres. Extended surveys were begun November 1st, last, to determine the area and quality of these bottom lands, the possibility of diverting water to them, and the probable expense of their reclamation. To this end a hydrographic survey of the region was begun, including the gaging of the river, the location of canal lines, soil analysis and the determination of silt and evaporation; and a topographic map of the lands upon which distribution systems may be considered was made. This map, on which the topographic features are clearly and accurately shown, will be of great value in assisting engineers to locate the main canal lines, and is essential to a comprehensive knowledge of the river as a whole. About one hundred men engaged in these investigations for the United States Geological Survey, Mr. E. T. Perkins being in charge of the engineering field work, Mr. E. C. Barnard in charge of the topographic mapping, and Mr. J. P. Lippincott, resident hydrographer for California, consulting engineer for investigations.

The demands for irrigation in the Colorado Valley are urgent. The average rainfall at Camp Mohave is only 5.99 inches per annum, and at Yuma it is 3.06 inches per annum, while the temperatures are such as to provide twelve growing months in the year.

The Colorado River derives its principal source of water supply from melting snow on the high mountains of Utah, Colorado and Wyoming. It reaches the stage of maximum flow—approximating 50,000 cubic feet per second—in the months of May and June, when the demand for irrigation is normally at the highest; its minimum flow—about 4000 cubic feet per second—occurs in the months of January and February, at the time of least demand. The opportunities for storage on this stream are very great.

The silts of the river are difficult to handle in canals, but the fertilizing properties which they have are such that lands irrigated with these muddy waters will never require further fertilization.

Mr. R. H. Forbes, of the Agricultural Experiment Station at Tucson, Ariz., who has made a study of the silt in the Colorado River, has pointed out that this stream resembles the Nile in many particulars. Like the great river of Egypt, the Colorado is subject to an annual summer rise sufficient to overflow the extensive areas of its borders and delta lands. These high waters are rich in fertilizing sediments, are exceptionally free from alkaline salts, and come at an opportune time for irrigation. Mr. Forbes maintains that when the Colorado is understood and utilized as successfully as the greater and better known Egyptian stream, it will be recognized as the American Nile—the creator of a new country for the irrigator, the mother of an Occidental Egypt.

THE SITE OF THE NIMSHEW PLANT.

HEREWITH is given a half tone reproduction of a photograph taken in May last of the site of the Nimshew power house of the Valley Counties Power Company, which is a strikingly typical representation of the character of country which Nature usually decrees shall be selected as the location of Sierra power houses. It has come to be looked upon as fate by some transmission engineers, and especially those of systems which are affiliated with the Bay Counties Power Company, that if power is to be developed from any watercourse, the very worst and most inaccessible spot in the river canyon will prove to be the only one which will satisfy the demand of the water power development. Though this is somewhat of an exaggeration, it is pretty close to the truth in the case of the Nevada County power house, as it is also in the present case of the Nimshew power house.

THE SITE OF THE NIMSHEW PLANT

This power house is now being built in Butte County, Cal., and its maximum capacity will be 12,000 kilowatts, of which contracts for 8000 kilowatts in generator capacity have already been given. Its generators are to be of the "S.K.C." inductor type, two of which will have a capacity of 2000 kilowatts each (being duplicates of the Stanley generators in the Colgate power house of the Bay Counties Power Company), while the third generator will have a capacity of 4000 kilowatts and will be remarkable in that it will run at the high speed of 400 revolutions per minute, giving a peripheral velocity of over 14,000 feet per minute. It will be the largest generator on the Pacific Slope, and it can well be imagined that it requires no small degree of constructive engineering skill to transport and erect such colossal machinery in such a "perpendicular" country. Wheels of the Pelton type are to be used, and they are to be supplied with water under a head of 1537 feet, through some 6000 feet of pipe line. It may be added that the output of the Nimshew plant will be delivered into the transmission circuits of the Bay Counties system.

A NOTE ON THE LIFE OF CREOSOTED FIR POLES.*

BY A. T. KINSEY.

TIMBER is used for poles in preference to iron or steel, chiefly on account of its lower cost, which may be one-third of that of iron. Some means of preparation of the timber, so as to render it capable of resisting the attacks of dry and wet rot, are, however, necessary; various treatments have been tried and abandoned, creosoting being the only method of any practical value and the only one much in use in Great Britain today.

One of the best timbers for poles is Norway red fir, but any timber that is used must be thoroughly seasoned and dried before treatment. The quantity of the preservative injected is eight pounds per cubic foot. It does not penetrate to the heart of the pole, but when the timber is very dense it goes only an inch or two. There is an unprotected portion—viz., the heart and interior margin of the zone through which the creosote penetrates. It is in this unprotected zone that the dry rot usually sets in, taking the creosoted zone and leaving the heart more or less intact, with the outside skin of the pole unbroken or marked. Dry rot is comparatively rare. It is found that in the course of time the creosote sinks from the top to the butt of the pole, forming a thick crust on the surface of the latter, where it is most needed as a protection against wet rot, which attacks from without and proceeds inwards.

In 1880 the life of treated poles in England was found to be thirty years. Poles taken down in that year which had been planted in 1849 and 1850 were found to be in all respects as sound as when erected. Since that date creosote has deteriorated in quality owing to the increased value of some of its constituents, and the author had thought it time to investigate the matter again. He had traced the erection of creosoted poles in Ireland as early as 1858, and again in 1860–61, but the systematic branding of the date of creosoting upon the poles with a hot iron was not begun by the department until 1873, and it is, therefore, impossible to identify with certainty poles creosoted before that date. But as a result of examination by percussion of the poles thus branded, at the butt and twenty-four feet up, he is able to state that they are still apparently quite as sound as when first erected; and there is an unbroken series of poles branded from 1873 to the present year.

Poles dated in 1877 were being taken down in quantity and stacked, and would pay for re-erection, after a quarter of a century's standing being apparently as good as new. I do not wish to be understood as stating that poles erected prior to the date named were not equally good. Judging by appearances there were plenty of poles much older.

* Abstract from *The Electrician* (Volume L, page 485, January 9, 1903) of a paper read before the Dublin Local Section of the Institution of Electrical Engineers, December 12th.

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EDITORIAL.

THE FIRE-FLY'S SECRET.

Ever since lighting by means of electricity came to human knowledge, or rather it should be said that ever since scientists began to investigate the efficiencies of different means of effecting artificial illumination, it has been averred times without number that when we shall have solved the secret of the fire-fly's light then shall we have discovered the illuminant that shall be of perfect efficiency. As the sluggard was admonished to go to the ant, to "consider its ways and be wise," so by common consent scientists have regarded the fire-fly as possessing the key to the great unfathomed mystery in the art of illumination.

But what is the fire-fly's light? What advance has been made toward solving the riddle of its production?

Natives of the Pacific Slope who have never been east of the Rockies know naught but that of hearsay concerning these harmless little insects that add further charm to the long delightful twilights of the Atlantic seaboard. Hither and thither they dart in dainty lines of phosphorescence, carrying cheerfulness everywhere, yet always reminding us, in their gentlest way, of man's finiteness. The light emitted by them is of a greenish-white cast, but beyond this it is, as a well-known handbook* states, most "unique and extraordinary in its properties. So far as can be ascertained, the total radiant energy of the fire-fly's light lies entirely within the limits of the visible spectrum, and not only there, but actually in its most brilliant part. No similar distribution of radiant energy is elsewhere known." When examined in the spectroscope the light shows a brilliant band extending over the yellow and green and fading rapidly as the red and blue are approached.

*"The Art of Illumination," by Louis Bell, Ph. D., pages 136-7.

In all probability Langley has investigated the light of the fire-fly with greater thoroughness than any other scientist, basing his researches on examinations made of the *Pyrophorus noctilucus*, a species of fire-fly found in the West Indies. They each attain a length of one and one-half inches and their light-giving properties are such that six of them, when placed in a bottle, give sufficient light for reading. These insects give spectra bright enough to permit of careful investigation, and from their light Langley has plotted curves which bring out a startling comparison between solar light and that of the insect.* From these curves it appears that the light of the *Pyrophorus* possesses a much less range of color, yet is much the richer in yellow and green than solar light. The maximum intensity is very near the beginning of the clear green (at about wave length 5500 of the spectra), and the light extends only a little way into the red and blue. The limits of radiation from the insect are indeed very narrow, being practically confined by the solar lines *C* and *F*, and Langley's most careful experiments have shown nothing perceptible outside of these limits. This is a very remarkable condition, for it stands alone in human knowledge of radiation.

If the judgment of the layman is to be accepted, the source of the fire-fly's light rests in an electrical phenomenon; but the scientist ascribes it to chemical changes at low temperature, such as the slow oxidization of some substance produced by it. Of its efficiency Langley found that the *Pyrophorus* expends only about one-four-hundredth of the part of the energy of a burning candle, from which it appears that the efficiency or the insect as a light producer is about five candles per watt, which is held to be by another authority† the equivalent of an efficiency of 100 per cent. This represents an efficiency from fifteen to twenty times that of the incandescent lamp, and about four times that of the arc lamp, which is at least startling. Langley's photometric curves for equal amounts of sun light and fire-fly light show that the latter is too nearly monochromatic to be satisfactory as an illuminant for general use.

One never forgets the Hallowe'en experiment with the sodium flame, wherein the light from a flame of alcohol containing common salt gives ghastliness to every one and everything about. Objects which appear yellow in daylight take on a greenish tint, red looks black, and the faces of those present are of a spectral greenish blue, relieved by purple. Then, as if countenances were not already sufficiently uncanny, red cheeks become black blotches, completing the horrors of this torture chamber of childhood. As to the reason for this, the sodium flame contains no red rays; neither does the light of the fire-fly contain red rays, nor are red rays contained in any vacuum tube lamp, prominent among which now is the Hewitt mercury vapor lamp.

*These curves are reproduced in Bell's "The Art of Illumination," page 137.

† *The Electrical Review* (London), Volume LII, page 87, January 15, 1903.

Clearly then the light of the fire-fly, together with that of its artificial prototypes, will not spring into universal popularity at a bound, despite their extraordinary efficiency and their great utility in certain lines of illumination, unless, perchance, it be within the range of possibility to obtain a combination of substances which would give light of better quality, and particularly a light which shall, like sun light, be polychromatic.

Nevertheless the Hewitt inventions are of the greatest interest, not only for their intrinsic worth, but also from their value as a contribution to scientific research. As it is, they are the nearest approach to the much-lauded fire-fly's light yet invented, and more than this they have taught us that the light of greatest efficiency in not the light which would be accepted by our civilization as an ideal, for money (*i. e.*, efficiency) is not everything—at least it is not thus far. And he who would attempt to educate modern society up to the acceptance of a no-red-ray light, would build a bridge to the moon.

Another page of this issue describes in detail the essential features of the Hewitt lamp, as well as of the Hewitt static converter, both of which are as promising in ultimate commercial importance as they are in present startling novelty. They at least command admiration, and it may be that hidden deep within the possibility of their developments lie the inventions that are to work the long promised revolution in the economics of present electro-industrial methods. If so, the secret of the fire-fly is one that shall be proved to be well worthy of the infinite study which has been given to it.

THE BERLINER PATENT A BAUBLE.

All the current electrical weeklies comment at length upon the decision of the United States Circuit Court of Appeals, handed down in Boston on January 16th, in the final effort of the American Bell Telephone Company to uphold its quondam monopoly in the telephone field through the instrumentality of the famous Berliner patent No. 463,569, and one of these publications* prints the decision in full.

The substance of the decision is that the Berliner patent referred to is valid *in so far as contact between metallic electrodes is concerned;* that Hughes invented the carbon microphone and that Edison invented the commercial transmitter, the patents for which were issued on May 3, 1892, but were void *ab initio* owing to the expiration, previous to their grant, of his English patent on the same invention. But one interpretation is to be given to the decision, which is that although the Berliner patent is valid, users of carbon microphone transmitters do not infringe it, for modern transmitters are based upon the Hughes and Edison inventions, the patents for which have since expired.

The Court thus summarizes its conclusions respecting the variable resistance transmitter:

We find that Bell, in March, 1876, discovered that the minute atmospheric vibrations due to sound waves would cause the diaphragm to vibrate, which vibrations, by varying the pressure between a solid electrode and a liquid electrode in constant contact, produced vibrations of electrical resistance, whereby speech may be transmitted.

We find that Edison, in February, 1877, discovered that the minute atmospheric vibrations due to sound waves would cause the diaphragm to vibrate, which vibrations, by varying the pressure between two solid electrodes of different conducitivities in constant contact, one metallic and the other hard rubber covered with a plumbago film, produced variations of electrical resistance, whereby speech may be transmitted.

We find that Edison, on April 1, 1877, discovered that the minute atmospheric vibrations due to sound waves would cause the diaphragm to vibrate, which vibrations, by varying the pressure between two solid electrodes in constant contact, one metallic and the other compressible plumbago, produced variations of electrical resistance whereby speech may be transmitted.

We find that Berliner, on April 14, 1877, discovered that the minute atmospheric vibrations due to sound waves would cause the diaphragm to vibrate, which vibrations, by varying the pressure at the point of contact between metallic electrodes in constant contact, produced variations of electrical resistance, whereby speech may be transmitted.

All of these discoveries, when embodied in transmitters, were inventions, but none of them was a commercial instrument, or solved the problem of a practical long-distance speech transmitter.

We find that, in the fall of 1877, Edison discovered the carbon electrode; that this discovery represents the first marked advance in the transmitter art since the 1876 Bell patent; and that the carbon electrode is found in every commercial battery transmitter.

We find that in May, 1878, Professor Hughes discovered microphonic action, or the fact that sound waves produce remarkable variations of resistance at a loose or feeble contact between solid electrodes in constant contact, whereby speech may be transmitted; that the principle he then made known is utilized in every practical battery transmitter; and that he embodied his discovery in an instrument, which he was the first to term a microphone.

We also find that Edison's discovery of the carbon electrode and Hughes' discovery of microphonic action solved the problem of a variable resistance transmitter, whereby speech may be transmitted long distances; and that both these discoveries are embodied in the defendants' transmitters.

We also find that the two claims of the Berliner patent in suit, although upon their face open to the objection of excessive breadth, may be sustained when read in connection with the specification, provided they are limited to metallic electrodes, and that, when so limited, the defendants' transmitters do not infringe.

Our conclusion is that the decree of the Circuit Court must be affirmed on the ground of non-infringement.

The decree of the Circuit Court is affirmed, with costs for the appellees.

This probably vanquishes the Bell company forever from recourse to the courts to bolster up its tottering monopoly, and it confirms the opinion long since expressed in these columns* that the Berliner patent referred to is naught but a "bludgeonless bogy."

AN EXAMPLE OF PROPER ENGINEERING.

A valued London electrical contemporary,† in commenting upon the leading article in THE JOURNAL for December last upon the power transmission system of the Northern California Power Company, observes "that it contains features of very considerable interest to the engineer. The transmission line itself is but some thirty miles long,

Western Electrician, Volume XXXII, page 73 *et seq.*, January 24, 1903.

*THE JOURNAL, Volume IV, page 99, August, 1897.

†*The Electrical Engineer* (London), Volume XXXI, N. S., page 77, January 16, 1903.

but the chief interest lies in the source of water supply for the plant," which readers of THE JOURNAL will remember "is a small creek rising from springs." "For this reason," to continue the quotations from our contemporary, "the water supply for the plant differs from a majority of mining streams in that its flow is constant throughout the year. * * * The system is instructive as showing that waterfalls or mountain torrents do not constitute an indispensable condition to the utilization of water power in the generation of electricity, and that with proper engineering even the more insignificant of natural streams may be turned to account profitably in the development of the electrical industry."

THE UNEXPECTED HAPPENS.

Human ingenuity has been exhausted seemingly to the utmost to render electric power stations immune from injury by fire, yet, as is related on another page, the bridge carrying the low tension cables from the great Niagara power plant to the transformer house across the canal has been burned, paralyzing the industries depending on electrical power thereabout for a period of some twenty hours. This unthought-of accident has taught well the lesson that insulated cables present a potent hazard, for it was the burning of insulation and naught else that wrought the havoc. Clearly, then, insulated cables must be rendered fire-proof, even though it be at the expense of iron armored conduit, or, perhaps, even ribbon-steel sheathing.

But as to power houses, what constitutes good, safe, fire-proof construction?

The fireproofing of power houses for electric transmission purposes has hardly settled into a standard type as yet on the Pacific Slope, but one of the buildings which is more nearly perfect in this regard than any other in California is that of the Standard Electric Company, at Electra, in Amador County. The water wheel and generator building is 208 feet in length by approximately forty feet in width. Abutting the end of this building and separated from it by independent walls is the transformer room, having a width equal to that of the generator room and a depth of practically 111 feet. Beyond this building and closely abutting it is the high tension switch building, which is of brick. These three buildings are in line, and run practically east and west, while to the south of the high tension switch building, and separated therefrom by a distance of twenty feet, is the lightning arrester building, which is of wood frame covered with corrugated iron—which, by the way, can bring forth no endorsement. The plan is for current from the generators, which is developed at 2400 volts, to be carried forward through the successive stages on to the line without doubling back. The transformers are designed to deliver ultimately 60,000 volts, but at present they are running at 30,000.

The generator and water wheel building is of steel truss construction throughout, and is supported on concrete foundations with concrete flooring. Over the angle iron frame work forming the sides and roof of the building, there is placed wire netting having a two-inch mesh. Upon this netting is wired asbestos cloth, which is in turn covered by P. & B. building paper, which is then covered throughout with corrugated iron. It should be understood that as a rule transmission power plants in California are not exposed to extreme cold, which leads to the belief that while this form of construction is thoroughly satisfactory in California, it would not answer the purposes of a plant in more rigorous climates. This particular building does not contain a stick of wood, and within it all circuits are handled from an elevated switchboard gallery adjoining the transformer house, the distinctive feature of which is the fact that the transformers, which are oil insulated and water cooled, are supported upon eight-inch I beams which span a concrete duct. This duct is perhaps six feet in width and varies in depth below the floor line from one to six feet, sloping into the tail-race. Its purpose is to carry off into the tail-race any and all oil that may be spilled from a transformer in event of accident or fire. In addition the transformers are mounted on iron cars with wheels that stand on rails, and so arranged that it takes but a few moments to wheel them out through up-lifting sliding doors into the open air. On account of the extreme high voltage used, this transformer building is floored wth wood resting on concrete.

The high tension lines are taken out from the high tension switch building and into and from the lightning arrester building, as well, through sewer tiling, which is thirty-six inches in diameter, and in the bell of which is secured plate glass having a circular opening in its center six inches in diameter. While this method of exit for high tension wires is probably not as good as that adopted in the Canyon Ferry station of the Missouri River Power Company, near Helena, Mont., wherein the 50,000-volt lines are taken directly through the roof by means of roof insulators, it is, nevertheless, very satisfactory.

To summarize, and speaking from a local standpoint, the type of walls and roof which is exemplified in the Standard generator station above described is the best to be found in California. If generators deliver low potentials, it is well to favor concrete floors throughout, with the handling of the apparatus confined to a switchboad gallery where adequate precautions for the protection of employees can best be taken. In many instances stone is available for building purposes near the site of the power houses, as, for instance, in the Colgate power house of the Bay Counties Power Company and in the Cow Creek power house of the Northern California Power Company. In southern California monolithic concrete construction is generally favored.

But above all, remember the self-evident truth that any material which is inflammable will burn, whether that material be wood-work, oil-soaked floors or insulated cables. The one is no worse than the other—then make them all fire-proof, everyone. Find the will to do it—the way will follow.

Four Institute "Introductories" on Transmission.

IN these columns for January* there appeared an announcement of the appointment of a committee, known as the Committee on High Tension Transmission, by the American Institute of Electrical Engineers, for the purpose in general of collecting data respecting present practices and successful methods in electric power transmission at high voltage; "in a word," continues the announcement, "the endeavor will be to make this committee the clearing house for experience and ideas bearing on high tension transmission."

The first efforts of this committee are now in evidence in the papers which appear below, and each of which is submitted as an "Introduction to a Discussion" upon the particular topic indicated in its title, and upon which subject Institute members are requested to express their opinions either personally or by letter, before the regular meeting of the Institute to be held in New York City on March 27th, next. In contributing to a discussion, it is requested that the matter under discussion be taken up under the several heads, and in the manner made use of in the "Introduction," and that following the treatment of these heads, there be introduced any other matter which the "Contributor" may deem advisable. When a member takes part by mail in more than one of the discussions taking place at the same meeting, it is requested that he embody his several "Contributions" in separate letters.

The scope of these "Introductions," the prominence of their authors, and the fulness of their experiences, together with the thoroughness which is always characteristic of Institute discussions, give abundant evidence of the growing importance of the Transmission Committee. That it will become most potent in the influence it will exert upon transmission engineering is not to be doubted.

Although not embodied in Mr. Blackwell's paper, the accompanying illustrations of high tension insulators under test at the Oakland substation of the Standard Electric Company of California, are here presented for the first time as a fitting contribution to the discussion. The photographs from which these half tones were made were taken under break-down tests, wherein the potential used at the instant of photographing ranged between 120,000 and 130,000 volts at sixty cycles. The insulators and pins used in the test were identical with those specified in Figure 1 of Mr. Chesney's paper, which follows, and the testing set was of the standard Stanley type, which has been described in these columns heretofore.†—THE EDITOR.

THE TESTING OF INSULATORS.‡

BY F. O. BLACKWELL.

ELECTRIC power transmission cannot be successful unless it is able to deliver uninterrupted power. Continuous operation, so far as the transmission line is concerned, depends largely upon the effectiveness of the insulator which is employed. Insulators must, therefore, be obtained which will not fail in service, and this can only be assured by the thorough testing of each one that goes on the electric lines.

The potential that can be employed safely for the transmission of power is now limited by the pressure the insulators will bear.

Transformers that are reliable and not excessive in cost can be built for twice the voltage that any line yet constructed will withstand.

As the distance over which power can be transmitted with a fixed cost of conductor varies with the potential, the length of transmission lines is to a great extent limited by the insulator.

The design of new and improved types of insulators is, therefore, most important, and these can only be developed by experiment with adequate testing facilities. In order to ascertain the value of such insulators, no method of testing can equal a practical trial under conditions of actual service. Placing new insulators on power transmission lines in commercial operation is impracticable in most cases and should only be permitted after they have successfully withstood tests to demonstrate their ability to stand operating conditions. These tests should duplicate as nearly as possible the electrical and mechanical strains set up in the insulators under the very severe conditions that would ever be met with on a transmission line.

There are certain facts which must be considered if correct deductions are to be made from insulator tests. For instance, we cannot test each insulator with a given number of volts continuously as it would be in service. As is well known, all insulating materials are most apt to break down on long applied electric stress. The prepared cloth wrappings used on the windings of electrical machinery will stand instantaneously two or three times the potential that they will carry continuously. Glass and porcelain are not affected by time to the same extent as organic materials, but we know that both are punctured by long continued applications of lower pressures than they have withstood in test.

The shape of the potential wave also has a pronounced effect in breaking down insulation. A wave may be either flat-topped or peaked, so that the maximum instantaneous potential is much less or greater than that of a sine wave of the same square root of the mean square potential. We might have for the same potential as read by the voltmeter, maximum instantaneous potentials which differ as much as two to one.

In air, the maximum point of the wave determines the distance which the current will jump. Different generators or even the same generator under different conditions of load will show widely varying arcing distances for the same potential.

Insulating materials being more affected by time than air, show in their ability to resist puncture that the average potential of the wave is more important than the maximum.

It is not safe to assume the potential either by the voltmeter or air gap as the true potential for determining the insulating value, as it is somewhere between the two. Moisture in the atmosphere also affects the arcing distance. In steam, a given potential will jump twice as far and in a fog 25 per cent. farther than under ordinary conditions. Of course, if the altitude is high and the air more rarified, the arc will also jump a greater distance.

I would like to call attention to the characteristics of the apparatus required for testing insulators.

The alternators generally used for long distance transmission plants give very nearly a sine wave and therefore the testing generator should be one which will give a sine wave under all con-

*THE JOURNAL, Volume XIII, page 105, January, 1903.

†THE JOURNAL, Volume XI, page 180, July, 1901.

‡Advance copy—subject to revision—of an "Introduction" to a discussion to take place at the regular meeting of the American Institute of Electrical Engineers to be held in New York City, March 27, 1903.

ditions. It is not sufficient to do so at full potential and no load, as tests are made with all degrees of excitation and with both leading and lagging currents.

The armature reaction should be as small as possible, which means that the generator should be much larger than would ordinarily be thought necessary. It is also desirable to have a high reluctance in the magnetic circuit to secure stability when running with weak fields and permit of control with a reasonable amount of field resistance.

There should be but one transformer used to step up to the highest potential required and its reactance should be as low as possible. A number of transformers in series is particularly bad, as it gives poor regulation and leads to great uncertainty as to the actual potential to which an insulator is being subjected.

I have known testing sets with transformers in series and a generator of poor regulation to vary widely in the relation of the generator volts and the length of the spark gap due to change of wave form with different magnetic saturations of the apparatus and different numbers of insulators and consequently various capacities on the testing circuit. The only certain way to determine the real potential is to have a step-down instrument transformer on the high potential circuit.

Assuming that insulators are to be passed upon for a specific transmission plant, they should first be inspected to see that they are free from cracks, bubbles or pits that will impair their strength or in which moisture can lodge. If of porcelain, the glaze should cover all the outer surfaces. The glaze is of no insulating value in itself, but dirt sticks to unglazed surfaces. Experience has shown that porcelain insulators which are not absolutely non-absorbent are worthless. The best porcelain shows a polished fracture like glass. If there is any doubt about the quality of the porcelain in this respect, it should be broken into small pieces, kept in a hot dry place for some time, weighed and immersed in water for a day. When taken out of the water the weight should be the same as at first. A puncture test should be made by setting the insulator in a cup of salt water, filling the pin hole also with water and slowly increasing the potential between the top and bottom until the desired test potential is reached or the insulator either punctures or arcs over the surface.

If an insulator is built up of several parts, each part should be able to withstand a pressure greater than it will have to sustain when the complete insulator is tested. If it is to be tested for 100,000 volts and is made in two parts, each part might, for instance, be tested with 70,000 volts. The object of this is to have the weak parts rejected before they are assembled. A fair puncture test for an insulator is twice the potential for which it is to be employed, applied between the head and the interior for one minute. For example, the insulators for a 50,000-volt line should each stand 100,000 volts. As the potential from any wire to ground on a 50,000-volt three-phase system would only be about 30,000 volts, a 100,000-volt test gives a factor of safety of nearly three and one-half to one. If one branch were grounded, as sometimes occurs in practice, the factor of safety would be but two to one. A one-minute test is not so severe as a continuous application of an equal potential, but insulators that have passed this test stand up well in service. New types of insulators should be mounted on iron pins and tested both wet and dry, to determine the potentials which will arc over them. The dry test is of little value, as the potential at which the arc jumps from the head to the pin can be pre-determined by measuring the shortest distance between them and referring to a curve of arcing distances in air. In a wet arcing test, a stream of water from a sprinkler nozzle under a pressure of at least fifty pounds to the inch should be played on the insulator at an angle of say thirty degrees from the horizontal. This will be similar to the condition which exists in a rain and wind storm. The insulator should not arc over from the wire to the pin at less than the potential which will exist in service between any two conductors.

In no case should wooden pins be relied on for insulation, as

their value is only temporary. All wooden pins in time become dirty and absorb moisture. Eventually they burn off unless the insulator is good enough to be used with an iron pin. If an insulator is going to fail, it is better to have it do so at the start and not interrupt the service by breaking down perhaps years afterwards.

In addition to the electrical tests, it is well (if the insulator is of a type that seems to require it) to try samples for mechanical strength. When mounted on pins the insulator should stand a side strain of at least ten times the pressure exerted by the air on the conductor with a wind velocity of, say, one hundred miles an hour.

It should also be able to slip the conductor through the tie wire should the former break.

These tests are particularly desirable with built-up insulators in order to be certain that the parts will not separate. With such insulators, it would also be well to test them in tension along the axis of the pin. In transmission lines crossing depressions, such an upward pull is not infrequently exerted on the insulator.

The above notes and suggestions are the result of the writer's tests of insulators and observations of high potential lines. There are many members of the Institute whose experience has been wider and who have doubtless given the matter much thought.

It is the purpose of this paper only to touch briefly upon an important subject in order to open a discussion which it is hoped will bring out much valuable information.

BURNING OF WOODEN PINS ON HIGH TENSION TRANSMISSION LINES.*

BY C. C. CHESNEY.

IN this country it has been almost the uniform practice in high tension pole line construction to use wooden pins. The reason for their use has been the belief that because they were made of wood they strengthened the entire insulation of the pole line system, and were in consequence additional safeguards. These pins have generally been made of locust, oak or eucalyptus, and in order that the insulation might not deteriorate from the action of the weather, they have usually been treated carefully with hot asphaltum, paraffine or linseed oil. The temperature and character of the treating liquid have depended more or less upon the whim of the constructing or designing engineer. Although there has been no uniform method followed and although the materials used in the treatment have differed greatly, the results have been universally the same. Wood pins when used with glass or well vitrified porcelain insulators, have given very good service on potentials as high as 25,000 or 30,000 volts. There has been no unusual pin troubles at these voltages which could not readily be explained by porous or cracked insulators or by some peculiar climatic conditions. In my opinion, the success secured in the operation of the great majority of these lines is due to good insulation of the insulator, and the insulation of the pin has in reality contributed very little to that success. For 40,000 volts and for higher potentials, the insulators offered by all manufacturers do not have the same factors of safety as the insulators for lower voltages offered by the same manufacturers. The difference is not so much in the thickness or in the quality of the glass or porcelain used; it is more particularly in the general shape of the insulator and in the dimensions of the insulating surfaces and petticoats. For this reason, even under severe local surroundings, the 10,000-, 15,000-, 20,000-, or 30,000-volt insulators have shown very little surface leakage, and in consequence there has been comparatively little pin burning at these voltages. It is true that in localities of salt storms, of heavy sea fogs or chemical factories, there has been more or less pin-burning without regard to the type of insulator used, or to the potential of the system.

The writer has been informed that a certain plant using only 440 volts has at times great trouble from the burning of pins, although 10,000-volt insulators are used. This trouble is due entirely to the deposit on the insulators from a neighboring chemical factory, and as might be expected their period of no-burning is during the rainy season. These instances, however, are rare, and when the cause is apparent, the remedy is usually at hand. The pin burning on 40,000- and 50,000-volt lines is somewhat different. Eliminating all causes due to broken or defective insulators, the actual flow of current over the surfaces and through the body of the pin is probably very small. On the lines from which the writer has secured burned pins two used 11-inch Locke insulators, as shown in Figures 1 and 2; the third used the Redlands type. The first two lines were operated at a potential

between 45,000 and 50,000 volts, and the third at about 33,000 volts. The pins shown were taken from perfect insulators and in some cases the insulators were immediately put back on the line. The pins shown in Figures 1 and 2 were made of eucalyptus and boiled in linseed oil. The line using the pin shown in Figure 2, also used a porcelain sleeve covering the base of the pin. Figure 3 shows the well-known Locke iron-pin with porcelain base and oak thread. In an exhibit of three pins, all of the type shown in Figure 1, these pins were taken from the same pole and occupied the relative positions as shown in the cuts and invariably the burnt sides stood towards the damp winds from the ocean. As other exhibits there may be shown burned pins of the type shown in Figure 2 as well as a Locke iron-pin with porcelain base, Figure 3,

*Abstract of a paper, advance copy—subject to revision—of an "Introduction" to a discussion to take place at the regular meeting of the American Institute of Electrical Engineers to be held in New York City, March 27, 1903.

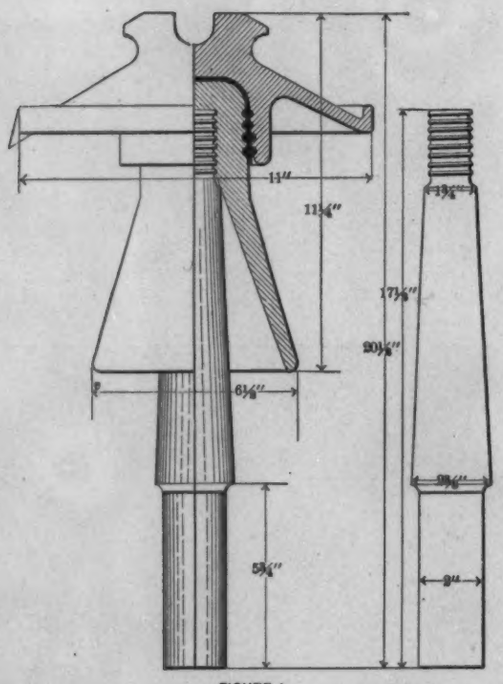


FIGURE 1

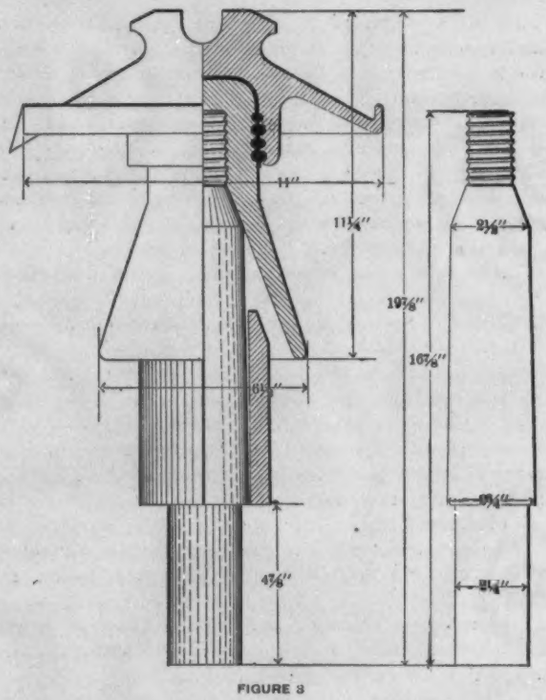


FIGURE 3

taken from a 33,000-volt line. The striking feature is the burning of the wooden thread to the iron pin. The writer has been informed by the general superintendent of this plant that every pin that has been examined on this line is burned in exactly the same way, yet there has been comparatively few punctured insulators and no cross-arms burned from the current leaking over the surface of the insulators. In a pin taken from a 50,000-volt line, the pin shown being sawed in sections, the noticable feature is that the burned section is entirely in the upper part of the pin about one and three-fourths inches below the thread. The outside surface and the center of the pin below this point shows no charring. It would appear that at least in this instance, the burned section was the point of highest resistance of the pin, and that the lower part of the pin was a good enough conductor to permit the small current which leaked over the surface of the insulator to flow without any special generation of heat in that section of the pin. The reduced insulation of the pin and insulator was no doubt due to the dust and fog. The upper portion of the pin, being better protected by the insulator from fog and dust, had in consequence higher surface resistance. A dark spot which appeared on the right hand edges of the lower section of this particular pin is the sap section of the wood which has been discolored by the linseed oil boiling which the pin originally had. This section has been in no way affected by the current. A peculiar action is occasionally found on high tension transmission lines, and for a better name, has been called "digesting the thread of the pin." The thread of the pin softens while in service and may be rubbed off with the fingers. This soft wood has a sour taste and resembles digested wood pulp. This action is not necessarily accompanied by the burning of any portions of the pin.

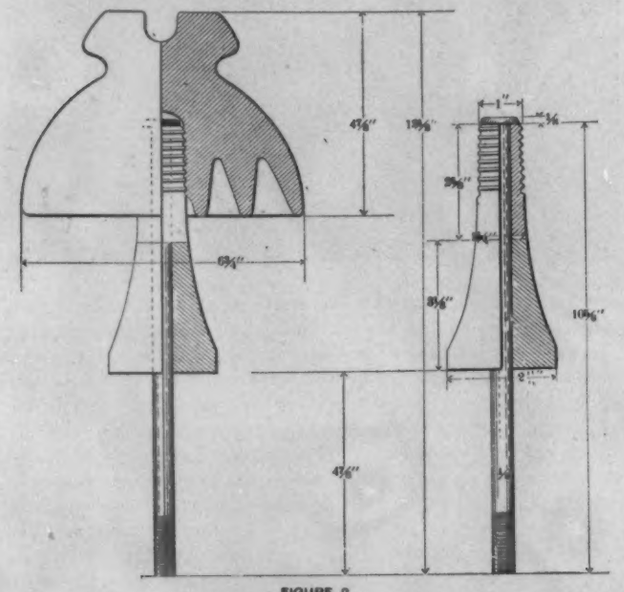


FIGURE 2

The evidence here presented, while not conclusive, still points to the advisability of using iron pins with modern insulators properly chosen for the line potential.

TRANSPOSITION AND RELATIVE LOCATION OF POWER AND TELEPHONE WIRES.*

BY P. M. LINCOLN.

FIRST consider that the extraordinary sensitiveness of the telephone receiver makes this instrument peculiarly susceptible to electrical disturbances. One authority states that the energy used in a sixteen-candle power incandescent lamp is sufficient to produce an audible sound in 30,000,000,000 receivers. The methods, therefore of shielding telephone wires from the inductive effects of neighboring wires become important. Particularly is this true in the case of a telephone line paralleling a high-tension transmission line, where the inductive disturbances are apt to be large, and uninterrupted service on the telephone line important.

(2) The remarks and discussion in this "Introduction to Discussion" apply particularly to telephone lines paralleling high-tension lines, but comments hereon need not be restricted to such cases.

(3) There are three ways in which disturbing current in telephone circuits may be caused by the high-tension circuit.

(a) Electromagnetic induction.
(b) Electrostatic induction.
(c) Leakage.

*Advance copy—subject to revision—of an "Introduction" to a discussion to take place at the regular meeting of the American Institute of Electrical Engineers to be held in New York City, March 27, 1903.

It is the first two causes of disturbances which will claim particular attention in the following discussion.

(4) Electromagetic induction may be briefly described as a transformer action. In Figure 1 let *a*, *b* and *c* be the conductors of a three-phase line, and *m* and *n* the two wires of a paralleling telephone circuit; *a* and *b* may then be regarded as the primary and *m* and *n* as the secondary of a transformer. The electromotive force in circuit *mn* will depend, among other things, upon the amount and frequency of the current in the inducing circuit. By transposing *m* and *n* in the well-known manner, the electromotive forces set up in one part of the telephone circuit will be neutralized by equal and opposite electromotive forces set up in other parts. Thus the electromagnetic effects between *m* and *n* may be entirely neutralized by transposing the telephone wires only, regardless of whether the transmission wires are transposed or not. It may be well to note, however, that while the electromotive force between the two telephone wires may be reduced to zero by properly transposing the telephone wires only, the electromotive force between the two telephone conductors considered as one side of a circuit and the earth as the other, can be reduced to zero only by transposing the power wires. This point is of little importance, however, as any electromagnetic electromotive force between the telephone wires and ground is entirely overshadowed by the electrostatic which will be considered later.

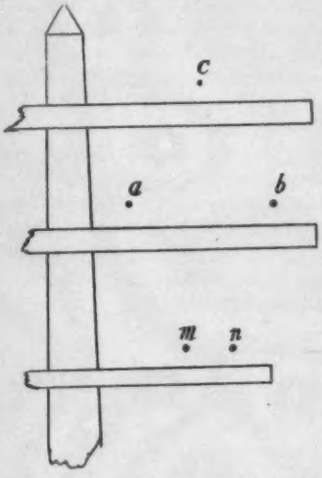


FIGURE 1

(5) Electrostatic effects will also take place in *mn*, due to transmission circuit *a*, *b*, *c*. If conductor *a* has a minus charge, for instance, it will induce a certain plus charge on *m* and a smaller plus charge on *n*, on account of *n*'s greater distance from *a*. If now the minus charge be removed from *a*, current will flow from *m* to *n*, proportional to the difference in the amounts of these charges. The electrostatic influence of *b*, being opposite to *a* in sign, will reinforce the action of *a*. Transposition of the telephone wires will have the effect of neutralizing this tendency of setting up electrostatic currents between *m* and *n*. It is important to note that a system of transpositions designed to correct electromagnetic induction between the wires will also be correct for electrostatic induction.

(6) Considering the comparative electromagnetic and electrostatic disturbances in a section of untransposed telephone line, it may be interesting to observe that the first is in the nature of a constant potential effect and the second of a constant current effect. It is evident that induced electromagnetic electromotive force is constant as long as the inducing current is constant. As for the electrostatic effect, it is evident that the amounts of the induced charges on *m* and *n*, and therefore the electrostatically induced current between them, will not become appreciably reduced until the current flowing between *m* and *n* makes a difference of potential between them appreciable, compared with the inducing difference of potential. With telephone receivers of varying resistance, therefore, the ampere turns in the receiver due to electromagnetic induction are practically constant, while those due to electrostatic induction increase with number of turns and therefore the resistance of receiver. The electrostatic and electromagnetic effect become roughly equal with an arrangement shown in Figure 1, when *a*, *b*, *c* is a line carrying fifty amperes at 20,000 volts, and the telephone circuit contains a total resistance of 1000 ohms, including receivers.

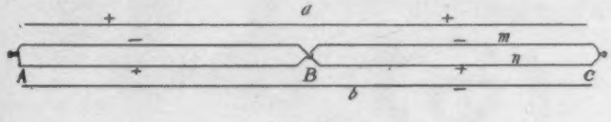


FIGURE 2

(7) The bridged telephone has almost universally taken the place of the series instrument for all telephone work. The series telephone is particularly objectionable for use on a circuit in which static induction takes place to any great extent. The reason for this is seen by an inspection of Figure 2. The telephone wire *m* has between *A* and *B* a plus charge induced and between *B* and *C* a minus charge. There is, therefore, at the transposition point *B* a flow of current from one section of *m* to the other. If now a series telephone be placed in series with *m* at *B*, it not only gets the benefit of this charging current between the two sections of *m*, but it also creates a difference of potential, and, therefore, disturbing currents in telephones at *A* and *C* as well.

(8) Although a proper system of transposition will prevent the establishment of an induced electromotive force between the two telephone wires, it does not necessarily prevent the two wires from assuming a potential which differs from that of the earth. In a properly transposed system each telephone wire is the same average distance from each power wire. The potential, therefore, which the telephone system tends to assume from the static induction of the power wires is that of the neutral point of the power system. By neutral point is meant that point between which and each of the power wires the average electromotive force is the same. Under normal conditions this nentral point is at ground potential. If, however, leakage takes place from one of the power conductors to ground, this neutral point will differ in potential from the ground and the amount of this difference becomes greater as the resistance of the leak becomes less. In a three-phase system, when the resistance of this leak becomes zero, the maximum difference of potential between the neutral point and ground occurs, and is 58 per cent. of the power circuit voltage. In a 20,000-volt system, for instance, there may exist a potential of nearly 12,000 volts between the neutral point and ground. When the neutral point of the power line differs in potential from ground, an electrostatic difference of potential tends to exist between the telephone wires and earth, and will exist if the insulation of the telephone circuit is perfect.

(9) The amount of this electrostatic potential between the telephone circuit and the earth will depend upon the relative capacities between power and telephone lines on one hand and between telephone line and earth on the other. The power and telephone lines may be considered as opposite plates of one condenser and the telephone line and ground as opposite plates of another condenser. These two condensers being in series, they will distribute the total electromotive force in inverse ratio to their capacities. With usual construction, the capacity between telephone line and ground will not be less than that between telephone and power wires, so that the potential of the telephone wires above ground will be equal to at least one-half the potential of the power line neutral point above ground. A grounded power line may thus cause a potential between the telephone wires and ground which will reach well into thousands of volts, and even a bad insulator may cause such an electromotive force measured by thousands of volts. In this connection it is significant to note that in the great majority of cases the telephones become inoperative when a ground occurs on the power lines. Is it any wonder? How many telephone lines are built to stand up under a strain of even 1000 volts, let alone 5000 or 10,000 volts to ground? It is hardly necessary to point out the path of the disturbing currents. The first voltage strain does not come between two telephone wires, but between the two wires and ground. A breakdown of its insulation, either partial or complete, occurs at some point, and the wire to which the break occurs discharges to ground either partially or completely, and the other wire must discharge through the telephones to the ground.

(10) The points, therefore, which deserve careful consideration in the installation and operation of a telephone line when it is to

be operated in proximity to a high-tension transmission line are the following:

(a) Insulation.
(b) Transpositions.
(c) Use of bridge telephones instead of series telephones.
(d) Making static capacity of telephone wires to ground as great as possible, and capacity to power wires as small as possible.

(a) Insulation.

(11) Insulation is put first as being the point of first importance. A ground in the transmission line is going to cause either volts or trouble on the telephone line. There is no reason why the telephone wires will not transmit speech properly, even if it does differ in potential from the ground. But to obtain this result disturbing currents from the line to earth must be prevented by perfect insulation. When it is realized that the potential between the telephone line and ground may be as high as 30 per cent. of the potential between power wires, the importance of insulation is better understood. By insulation, too, is meant the insulation throughout the entire line. There is little use in providing glass insulators for pole supports capable of standing a voltage of 15,000 or 20,000 and then inside buildings attaching the telephone wires directly to woodwork which may be damp, or to an instrument mounted on a damp brick wall. Above all, there is no use in putting up a line which may be able to stand a test of 15,000 or 20,000 volts, and then attach to this same line a lightning arrester which will break down at 300 volts, as the standard telephone lightning arrester is expected to do.

(12) When providing high-tension insulation for the telephone line, the insulation of the man using it should not be forgotten. The insulation of the telephone user is advisable, not only to protect him from the induced voltage, but also to protect him in case of cross with the power line. The induced voltage is not so dangerous as its amount would indicate because the current is limited to that of a condenser consisting of power line, as one plate, and the telephone line as the other. It may be noted that the telephone insulation is subject to high strains only when the power line is grounded or heavily unbalanced statically. This is just the time, however, that uninterrupted service of the telephone line is apt to be of the utmost importance.

(b) Transpositions.

(13) The necessity of transposing the telephone line is almost so apparent as not to need comment. Otherwise continuous disturbances will exist, due both to electromagnetic and electrostatic effects. So far as the telephone line is concerned, transposition of the power wires is not so important. An untransposed power line cannot induce either electrostatic or electromagnetic effects between two transposed telephone wires, but only between these two wires and ground. The amount the statically balanced untransposed power line can elevate the telephone lines above the ground potential is small compared to the effect of the power line when statically unbalanced, whether transposed or untransposed. If the telephone line is insulated to meet the worst conditions, it will be ample to meet the normal condition of an untransposed power line.

(c) Use of Bridge Instead of Series Telephone.

(14) This point is one which need only be mentioned. The advantages of the bridged over the series telephone are so well known that the reason before mentioned for using a bridged instead of a series instrument is only throwing another shovelful of earth on the grave of the series instrument.

(d) Making Capacity of Telephone Wires to Earth as Great as Possible, and Telephone Wires to Power Wires Small as Possible.

(15) In Montana there is a line in operation at 50,000 volts. Other lines are projected as high as 60,000 to 80,000 volts, and there is a possibility of going higher. When one realizes that with the usual construction, as shown in Figure 1, there may be in such cases an elevation in the potential of the telephone wires of 20,000 to 25,000 volts above ground he begins to cast about for some method of reducing this potential. The total voltage between the neutral point of the power wires and ground may be considered as taken up across two condensers, one consisting of the power and telephone wires, and the other the telephone wires and earth. To decrease the possible potential of the telephone wires to ground, therefore, one must either decrease the capacity of the power wire, telephone wire condenser, or increase the capacity of the telephone wire, earth condenser, or both. This may be accomplished by increasing the distance between power and telephone wires, and decreasing the distance between telephone wires and earth. If the same supporting structure be used, there is a limit to which this one can be carried, at which the possible voltage between telephone wires and earth may still be prohibitive. The capacity of the telephone wire-earth condenser may be still further increased by bringing the earth to the telephone wires, instead of the telephone wires to earth. That is, one or more ground wires may be run in close proximity to the telephone wires, thereby increasing the capacity of the telephone wire-earth condenser to almost any desired limit. By this means the possible potential between telephone wires and earth may be brought within limits where it may be taken care of with safety.

(16) In conclusion, the writer asks for the fullest comments on the foregoing remarks, particularly from those who have had experience in operating a telephone line paralleling high-tension wires. If such can agree with the writer in his remarks, he will be pleased to know it. If they cannot agree, he will be still more pleased to find out wherein he is wrong.

SPECIFICATIONS OF A PROPOSED INSULATOR PIN.*

BY RALPH D. MERSHON.

NO general standard exists at present in the matter of insulator pins. As a result there is often confusion and dissatisfacton in ordering and obtaining pins. This discussion of a proposed standard pin is intended to lead up to a general specification covering wooden pins, and, so far as it may, metal ones.

Theory—The expression for the extreme fiber stress at any point of a beam of circular section fixed at one end and loaded at the other, as in Figure 1, is

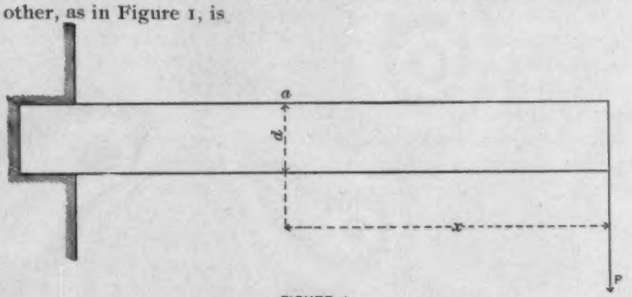


FIGURE 1

$$s = \frac{P\,x}{.0982\,d^3} \qquad (1)$$

where (assuming inches and pounds as our units) P is the pull or weight in pounds; x is the distance in inches from the point of application of P to any point a of the beam; d is the diameter in inches at the point a; s is the extreme fiber stress in pounds per square inch, *i. e.*, s is the stress on the extreme fibers at the top and bottom of the beam at the point a.

This equation shows that for a given pull P the fiber stress at any point a at a distance x from the point of application of P varies directly as x and inversely as the cube of d. It is possible, therefore, to design a beam of circular section whose diameter in passing from the point of application of P to the point of support shall vary in such a way that s will have the same value all the way along the beam. Such a beam will be of uniform strength

*Advance copy—subject to revision—of an "Introduction" to a discussion to take place at the regular meeting of the American Institute of Electrical Engineers to be held in New York City, March 27, 1903.

throughout its length. The value which, in such a beam, d must have at any point distant x from the outer end may be found by assuming s and P constant in equation (1) and solving for d in terms of x. This gives

$$d = \left(\frac{P}{.0982\,s}\right)^{1/3} x^{1/3} = K x^{1/3} \qquad (2)$$

where K is a constant whose value must be determined from the extreme fiber stress allowable with a given pull P. Equation (2) shows that in order to have the beam of uniform strength throughout its length, its diameter must vary as the cube root of the distance from the point of application of its load.

An insulator pin is the case of a beam of circular section fixed at one end and with a load (any side pull which may come upon it) applied at or near the other end. There is no object in having an insulator pin any stronger at any one point than at another. It should, therefore, in its capacity as a beam be tapered as nearly as practicable in such a way that s will be constant throughout, that is, so that equation (2) will apply to it.

The point where pins usually break, their weakest point, is just at the cross arm. The wooden pin most generally in use is one having a diameter of about 1½ inches in the cross arm and a length such that the wire is from 5 to 6 inches from the cross arm. Let us obtain the value of K in (2) on the assumption of $d = 1\frac{1}{2}$ inches and $x = 5$ inches. This gives the value of K as .877, so that, substituting, (2) becomes

$$d = .877\, x^{1/3} \qquad (3)$$

From (3) we may find the diameter required at any point in any length of pin, the pin to be of uniform strength throughout. Substituting various value of x we have the following:

x (inches)	d (inches)	x (inches)	d (inches)
1	.877	9	1.825
2	1.106	10	1.888
3	1.263	11	1.95
4	1.395	13	2.06
5	1.5	15	2.17
6	1.592	17	2.25
7	1.678	19	2.34
8	1.754	21	2.42

This table shows that for a pin having upon it a pull one inch above the cross arm, the diameter at the cross arm must be .877 inches; that one having a pull upon it ten inches above the cross arm must have a diameter at the cross arm of 1.88 inches, etc.

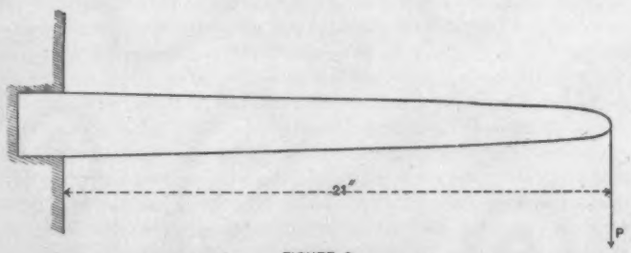


FIGURE 2

Figure 2 is a sketch of such a theoretical pin drawn by platting the above values to a scale one-quarter of full size. Figure 2 represents all sizes of pins up to and including one the pull upon which is applied twenty-one inches above the cross arm. That is, if we want a theoretical six-inch pin we must cut six inches off the end of Figure 2 and use that; for a ten-inch pin we must cut off ten inches, etc.

The practical pin must be a modification of the theoretical pin. The end must be square and a portion of the small end must be threaded. The pin must also have a shoulder just above the cross arm. It will be noticed that, except near the end, the sides of the theoretical pin are practically straight. It will suffice, therefore, if in designing a pin we fix the diameter at the lower end of the thread portion and the diameter just above the cross arm and make the contour between these points a straight line.

Threaded End—It is proposed to make the diameter of the small end of the pin one inch; the length of the threaded portion two and one-half inches, and the diameter at the lower end of the threaded portion 1.25 inches, so that the threaded portion will taper from 1.25 inches to one inch in a length of two and one-half inches. The threaded portion of the insulator should have the same dimensions and taper as that of the pin.

Shoulder—It is proposed to make the shoulder $\frac{3}{16}$ of an inch on all pins. That is, the diameter of the pin just above the cross arm will be $\frac{3}{8}$ of an inch greater than the nominal diameter of that portion of the pin in the cross arm; it is proposed to carry this diameter ¼ of an inch above the cross arm before tapering the pin.

Dimensions in Cross Arm—It is proposed to make the diameter of that portion of the pin in the cross arm, just below the shoulder, $\frac{1}{32}$ of an inch less than the diameter of the hole in the cross arm, and at the lower end of the pin $\frac{1}{16}$ of an inch less than the diameter of the hole in the cross arm. It is proposed, also, to designate this portion of the pin as having a nominal diameter equal to that of the hole in the cross arm into which the pin fits. Therefore, that portion of a pin which is to fit a one and one-half-inch hole in a cross arm will have a nominal diameter of one and one-half inch, but will have an actual diameter just below the shoulder of $1\frac{13}{32}$ inches, and at the lower end of the pin of $1\frac{7}{16}$ inches.

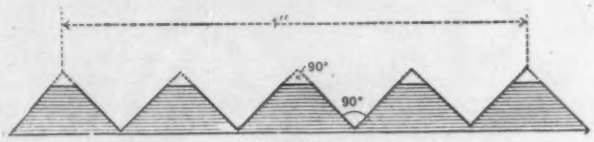


FIGURE 3

Thread—It is proposed to use on all pins a thread having a pitch of one-fourth inch or four threads to the inch, the form of thread to be that shown in Figure 3 (scale four times full size). As there shown, the angle between the faces of the thread is 90 degrees, and the top of the thread is flattened by cutting off, from the form the thread would have if not flattened, one-fourth its unflattened depth. The form of the thread in the insulator should be the same as that on the pin. If this is done it will insure the bearing surface being always on the sides of the threads and never on the edges.

Designation—It is proposed to designate that portion of the pin above the cross arm as the "stem" of the pin. That portion in the cross arm as the "shank" of the pin. It is proposed to designate a pin by the length of its stem, *i. e.*, a pin whose stem is five inches long will be designated as a "five-inch" pin, one six inches long as a "six-inch" pin, etc.

Dimensions of Standard Pins—In accordance with the above the following table has been prepared, giving a number of sizes of pins and their dimensions, which it is proposed to make standard. The diameter of the shank has in each case been fixed by making it approximately equal to (slightly larger than) the diameter of the theoretical pin corresponding to the length of the stem of the pin in question. The headings of the columns of the table refer to the lettering of Figure 4. Figure 4 is a full size unthreaded five-inch (proposed standard) pin.

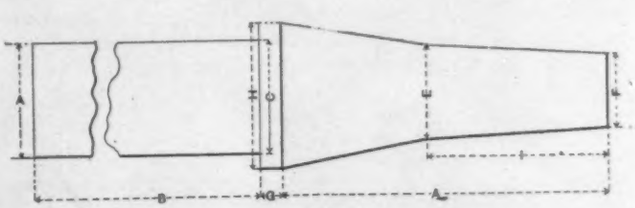


FIGURE 4

Size of Pin. Inch.	A Inch.	B Inch.	C Nominal. Inch.	C Actual. Inch.	D Inch.	E Inch.	F Inch.	G Inch.	H Inch.	I Inch.
5	5	4¼	1½	1 1/32	1 7/32	1¼	1	¼	1 7/8	2½
7	7	4¼	1¾	1 3/32	1 11/32	Same for all sizes of pins.	Same for all sizes of pins.	Same for all sizes of pins.	2 1/8	Same for all sizes of pins.
9	9	4¼	1 7/8	1 5/32	1 15/32				2¼	
11	11	4¾	2	1 7/32	1 19/32				2 3/8	
13	13	4¾	2 1/8	2 9/32	2 1/16				2½	
15	15	4¾	2¼	2 11/32	2 5/16				2 5/8	
17	17	5¼	2 3/8	2 13/32	2 5/16				2¾	
19	19	5¼	2½	2 15/32	2 7/16				2 7/8	

ELECTRIC POWER FOR MINING AND MILLING.*

IN presenting this paper, the aim has been to deal with results obtained in Amador County, Cal., using electricity at $6.50 per horse power per month, furnished by the Standard Electric Company of California, generated at their plant at Electra, Amador County, from which about 14,000 horsepower of alternating current is distributed through the central portion of the State. The transmission line along the mother lode from Angels Camp, Calaveras County, to the Fremont Mine, one and one-half miles north of Amador City, carries a 10,000-volt current, which is transformed at each mine to 550 or 600 volts for power purposes and 125 volts for lighting purposes. At the Fremont Mine the superintendent, C. E. Purrington, has installed a 20½x24 duplex Ingersoll-Sergeant single stage compressor, having a capacity of 1700 cubic feet of free air per minute. The compressor is operated by a 300 horsepower General Electric motor. The air is used for all purposes, hoisting, drilling and pumping water. The plant is only recently installed, so figures cannot be given accurately, but the superintendent informs me it is giving entire satisfaction. This plant is equipped with six air receivers of 1500 cubic feet capacity and several hundred feet of six-inch pipe for storage, besides the three steam boilers in which the air used by the hoisting engine is reheated. This compressor has a unique unloader, being an automatically regulated valve in the pipe through which the compressor takes air, which valve is closed when the air pressure reaches any particularly point it is set at. Of course, if the compressor sucks no air it pumps none, or practically so.

The Keystone Mine at Amador City saved $150 per month using electricity at $6.50 per horsepower month, as compared with water used under 185 feet fall at 20 cents per inch, formerly used in running this forty-stamp mill. They are now using compressed air for hoisting and drilling, the compressor being run by a 300-horsepower General Electric motor with a 550-volt current. This plant is only recently installed. At the Kennedy Mine a change from pine wood at $6 per cord in the furnace to crude oil at $1.50 per barrel was made, and it was found that $17 worth of oil did the same work as $24 worth of wood.

This paper deals largely in compressed air plants, for with the exceptions when electricity is applied direct to mill rock breakers, blowers and pumps, compressed air, apparently, is the only resort, which accounts for its prominence and as most mines are equipped with steam engines it is very easy to change from steam to air, as well as making it possible to fall back on steam in emergencies. As to electricity applied directly: Through the kindness of C. R. Downs, superintendent, and J. F. Phipps, assistant superintendent of the Bunker Hill Mine at Amador City, Cal., I am informed that it costs them just one-half as much to run a No. 10 Buffalo forge blower by electric motor as by an upright steam engine, and much less care and repairs. The blower runs 1700 revolutions per minute, blowing 4000 cubic feet of air per minute through 2000 feet of eleven-inch pipe at a cost for power of $1.06 per day. This blower is run by a ten-horsepower General Electric induction motor, consuming five horsepower, and when steam is used it costs $2.12 per day. Here they also have a 12x14 Ingersoll-Sergeant single stage compressor running at 160 revolutions per minute belted direct to a fifty-horsepower General Electric motor. Air is used for drilling and pumping. Until recently all the pumping was done by steam at 100 pounds pressure, and I am informed that they see no difference in cost of pumping by air or steam; it being about equal, with the advantage of having the air to use for drilling when needed. However, I believe from my experience at the South Spring Hill Mine that if the steam cyclinder end of the pumps were large enough in diameter to use at forty pounds pressure and keep up to speed, there would be a balance in favor of air against steam. They are paying $6.50 per horsepower month for electricity and $6 for first-class pine wood in the furnace. This was proven very satisfactorily at the South Spring Hill Mine where the pump running by compressed air was especially designed to work on air at forty-five pounds pressure, raising the water 725 feet vertically in one lift, the back pressure of the water at the pump being about 345 pounds to the square inch. This pump worked cheaper on air than it would by steam. Leakage and extraordinary heating of the air from compression make it advisable to use low pressure air whenever possible.

At the Oneida Mine electricity is applied direct, a General Electric 100-horsepower motor being geared directly to a Dow duplex plunger pump.* This pump raises 200 gallons of water per minute, about nineteen miners inches of water, 1300 feet vertically in one lift through a six-inch pipe for four and one-half hours daily at a cost of $3.40 per day for power—at $6.50 per horsepower month 100 horsepower of electricity is used; the actual weight of water raised 1300 feet represents sixty-five horsepower so that there is a loss of only thirty-five horsepower or 35 per cent. in drop on the line from the transformer to the motor in the mine, friction in motor, pump and pipe line, giving an absolute efficiency of 65 per cent. which compared with steam or air is about three or four times as efficient taking into consideration the amount of energy purchased.

W. R. Thomas of the Central Eureka states that it costs about one-half as much to run their blower by electricity as it formerly did by water at 20 cents per inch. When the water head is 500 feet or so I believe it to be about a standoff with electricity at $6.50 per horsepower month and water at 20 cents per inch for power purchased, with the advantage in favor of electricity by eliminating long and expensive ditch and pipe lines, with their constant repair, maintenance and delays due to breakage.

It is not necessary to cite other mines using electricity direct regarding its efficiency, and I desire to devote the remainder of this paper to the use of electricity for hoisting purposes, through the medium of compressed air. However, it seems very strange that a proper understanding cannot be had as to the feasibility of electricity applied direct to hoisting machinery.

The first essential to every compressed air plant is ample storage, so that a minimum size compressor can be used, running comparatively slow, and maintain the working pressure as nearly constant as possible. Air once stored can be used today or next week if properly stored. As to leakage, let me call your attention to this fact: At sixty pounds pressure air will travel through a pin hole at the rate of 600 feet per second, or 36,000 feet per minute, nearly seven miles per minute, so however small the hole is the volume is large where a steady steam is blowing away.

*A paper read by John B. Tregloan, Superintendent of the South Spring Hill Mine, Amador City, Cal., before the annual meeting California Miners' Association, San Francisco, November 17, 18, 19, 1902.

This paper should be read in conjunction with that of Mr. C. O. Poole upon "The Economy of Electric Power in Quartz Mining," which appears in full in THE JOURNAL for July 1902, (Volume XII, page 126 *et seq.*) and in the Transactions of the Sixth Annual Convention of the Pacific Coast Electric Transmission Association, page 79, San Francisco, 1902.—THE EDITOR.

*For details of this installation and its performance see THE JOURNAL, Volume XII, page 110, June, 1902.

The same rule applies to the blowoff, so use an unloader of some description, preferably one that holds the outlet valves open, allowing the compressor to be in absolute equilibrium, forcing air into the receiver from one side of the piston and drawing it from the receiver on the other, and *vice versa* on the return stroke. As to two or more stage compression I would say that it is the ideal way to compress air, but so-called two stage compressors are a farce, unless the intercooler is of sufficient size and proper design to return the air to something near the atmospheric temperature while it is passing from the low to high pressure cyclinders. The term "two-stage" is used a great deal to sell inefficient compressors.

It takes power to run a compressor sixty, seventy-five, or 150 revolutions per minute even if it is unloaded, so plan the size of compressor and storage so that it runs unloaded as seldom as possible, in fact only in emergencies. It is no more necessary to have the compressor running unloaded most of the time than it is to have steam blowing off continually because there is a blow-off valve on the boiler. With an induction motor and the alternating type of current used in this country it is not possible to start and stop the compressor to avoid blowing away air, so that must be accomplished by proper storage unloaders, and more important than anything else, a proper size compressor, neither too large nor too small, so that the aggregate amount of air used in twenty-four hours will be furnished by the compressor running at a speed not to exceed 200 feet of piston speed per minute with the stroke at least double the diameter of the cylinder, for economical results. Heavy flywheels are more essential on a compressor than on a rock breaker, although generally not so considered, to prevent any jerking on the rope transmission or belt. In a ten-inch diameter compressor, at the end of each stroke the pressure changes when pumping against 100 pounds pressure from a hold back of 7854 pounds to a shove ahead of the same amount, and the air left there due to clearance runs the motor for an instant.

A total change in tension on the belt or rope of 15,708 pounds, or nearly eight tons, a heavy fly is required to steady this motion, or it will jerk the life out of the belt or rope in a short time, as well as cause slipping. Avoid countershafts by a large diameter heavy rim flywheel on the compressor, and avoid a tightener on belt driven compressors, which takes power to run it 800 or 1,000 revolutions per minute, by placing the motor far enough from the compressor, using a wide belt, so that the weight of the belt, with the slack side on top, will be sufficient to prevent slipping, which is another item of loss.

Now as to the efficiency of compressed air for hoisting engines, how can one expect air to be thoroughly satisfactory when the largest portion of power goes up the exhaust pipe, as well as escaping, now and then, through the blow-off on the receiver. I mention this because I have seen several plants doing this very thing and those in charge complaining about their compressor, or the electric motor, or some other reason, whereas the compressor is all right and a good, willing friend, likewise the electric motor, but the type of hoist and the storage and other things arranged by the superintendent himself are the only faulty things about the plant. Electricity and compressed air are a comparatively recent factor with which all miners must sooner or later familiarize themseives, and when they meet this new factor with intelligence it will be as simple as hand drilling now is to the average miner. What would a superintendent say to his engineer if he continually had steam blowing off, or what would the board of directors say if there was a continual stream of water running over the waste gate of the reservoir? Yet just such extravagance has been and in some cases is being practiced with compressed air. Treat it as economically and intelligently as you would water power, wood, fuel oil, and with the electric current at not over $6.50 per horsepower month it will be your best friend.

Receivers should be close to the compressors, and, if possible, where the air is used for general purposes, run the air through an old boiler, submerged in water, which will compel the air, by cooling it, to drop what water is in it immediately and not drop it in the pipe line going down the shaft, so that it will not scour the pump cylinders and machine cylinders, as well as to a great degree prevent freezing at the exhaust, a common inconvenience. An old crosscut underground, bulkheaded with concrete, makes an efficient and at the same time large and cheap storage. Large piping and the absence of ninety-degree elbows are very essential for economy. So much for the air plant; now for the hoisting engine itself.

Use double compound tandem engines; in other words, take an ordinary double cylinder hoist and add a low pressure of about twice the piston area of the present one, extend the piston rod through the rear head of old cylinder into the low pressure, and with the cut-off added to the low pressure you have a double compound tandem hoisting engine. This allows starting the load with the two high pressure cylinders, instead of having to rely on the high pressure alone as in a duplex compound, with a high pressure on one side and a low on the other. Air does not condense like steam, so that the power in it is utilized till it has expanded to nearly atmospheric pressure.

As to reheating air the cost is only trivial, for every twenty-four pounds of good coal or its equivalent in wood in reheating air at about eighty pounds gage pressure an additional horsepower for twenty-four hours can be obtained. Whereas, under good conditions, it requires from ninety-six to 120 pounds of good coal to get one horsepower for twenty-four hours from steam, with first-class boilers modernly installed and operated. Using the steam boilers for reheating the air makes it possible to revert to steam in a few minutes at any time, in case of emergency, without loss of time.

I had charge of the planning and installation of the plant at the South Spring Hill Mine at Amador City. The compressor used is 10x18 duplex single stage poppet valve type, driven by a thirty horsepower General Electric induction motor, and formerly run by water power. In this case the blowoff, by use of an automatic valve arrangement at the air receiver, was led into the steam boiler, so that unless the hoisting engine was idle there was no air wasted; however, considerable air was in this case allowed to blow away on account of the compressor not being equipped with an unloader. When the pumps and drills were not in operation all the air went to the steam boiler, there being reheated and used by the engine. The largest amount of wood used for reheating purposes was one-half cord per twenty-four hours. Under these conditions the cost of the power to operate the hoisting engines was reduced to one-half, a larger economy than has been made by oil, due mostly to the fact that forty-five pounds gage pressure would haul the load, which means low pressure air. The compressor ran fifty-nine revolutions per minute, and furnished enough air to to run two drills (3⅛x3¼ Rand), breaking sixty tons of very hard ore per day, hoist the same 550 feet, and about eighty tons of water per day with the use of one-half cord of wood. The average consumption of electricity was about twenty to twenty-five horsepower per day, the bills varying from $135 to $160 per month, and were more than covered by the wood saved as compared with running the hoist entirely on steam.

In milling not much needs to be said, as there electricity is applied direct. Electric motors put at least 90 per cent. of the power purchased into the belt, which, of course, discounts water or steam at prevailing prices. It is easily and cheaply installed, is a clean power, should not fluctuate, has a permanent speed regardless of hot boxes or bearings, either one stamp or all of them can be hung up without an appreciable change in speed of the cam shaft. Concentrators can be started at will without varying the speed of others, giving a proper separation at all times, so that to the maximum extent possible, in a mechanical separation there is no sand in the concentrates nor any sulphurets in the tailings. Electricity is the miners' friend, and I trust that in the future, as well as now, those estimable gentlemen who are putting their brains, as well as capital, into these large electricity generating plants, will be working side by side with the miner,

for the miner will always be their nearest consumer, and as one prospers so will the other. Mines and mills need no longer be far apart, thanks to our electrical friends, and the advent of electricity, which travels with equal facility up hill as well as down, in sunshine or storm, unlike water, or teams, or railroads, and lays down at our very door, continually without interruption, ready harnessed for work, the greatest and most efficient power the world has ever seen, so that the miners can mine and mill on the highest mountain top as easily as in the valley, providing climatic conditions or the topography of the country do not preclude it altogether. As to electricity direct for hoisting purposes, it should be taken up and fathomed, for its successful application is a very important economic proposition.

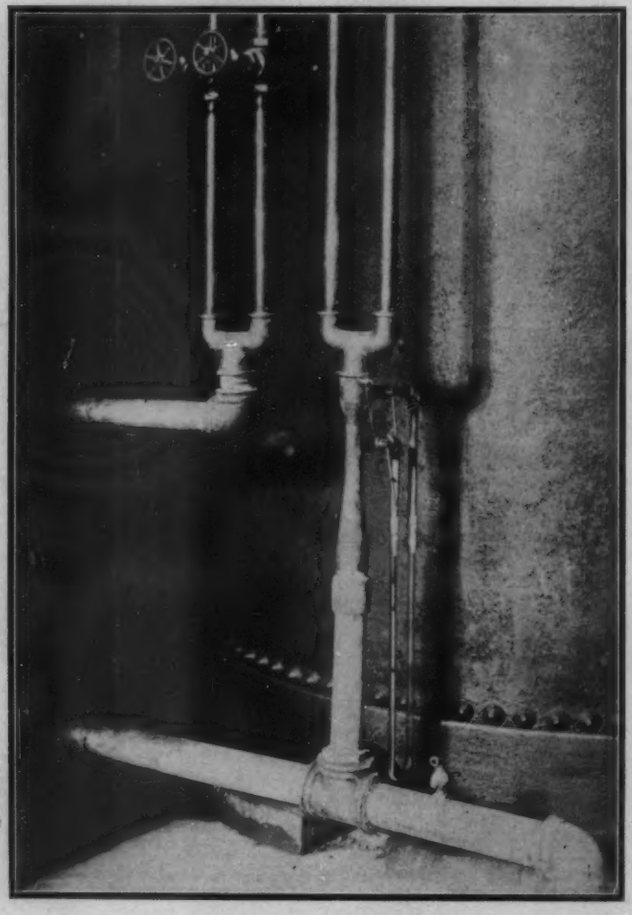
I desire to thank the various superintendents and others along the lode in Amador county for courtesies extended and data freely granted.

Three Interesting Innovations at Canyon Ferry.

One of the most instructive power transmission installations to be found in the entire Rocky Mountains district is that of the Missouri River Power Company, at Canyon Ferry, Mont., some eighteen miles easterly from Helena. The power house, which has been described in these columns heretofore* is of exceeding interest, not only in the matter of those details which have already been the subject of the preceding article, but in other directions, principally among which may be mentioned the methods adopted and in successful operation, the adaptation of the principle of the Venturi water meter for indicating the flow of water through the cooling coils of the transformers, the taking of extreme high tension lines from the building through roof insulators, and the section of the type of insulator installed on what is generally believed to be the highest voltage used in any transmission service in the world. These three features are the subject of the following contributions.—THE EDITOR.

A VENTURI WATER INDICATOR.

When oil insulated transformers are water-cooled, it is necessary that some visual indication be given of the continuity of the flow of water through the pipe forming the cooling coil. If the water for cooling purposes be applied under pressure, as is ordinarily the case, it becomes a simple matter to discharge the water into a funnel leading to the waste way, so that the amount of water that flows may actually be seen and any break in its continuity thus noted. But in the Canyon Ferry power house the raising transformers are so located that they are at times above the level of the water in the forebay, hence it was necessary to siphon the water through the transformer cooling coils. To do this in a way which would always be operative as a siphon and at the same time would enable the station attendant to see at a glance whether water was flowing properly through the pipe coils presented a problem which was solved in a very clever and ingenious way. Obviously the siphon principle precluded any actual break being made in the discharge pipe in order to run the discharge water into a waste funnel as is ordinarily done, so the principle of the Venturi water meter was utilized with results that have been highly satisfactory.



A VENTURI WATER INDICATOR

The Venturi water meter is well known to hydraulic engineers and its underlying principles have proven to be a favored theme for description.* The meter is peculiarly adapted for the measurement, to an astonishing degree of accuracy, of large volumes of water flowing through pipe lines, such for instance as water works' mains and pipe lines for high head hydraulic power plants, but singularly the only electric transmission station which is using the Venturi water meter west of the Rockies is the pioneer plant of the Utah Light and Power Company,† located in Ogden Canyon, four miles back of the city of Ogden, Utah. In view of the obvious fact that the Venturi meter is so infrequently used on the Pacific Slope, it may be stated to advantage that its basic principles are found in the hydraulic properties of diverging tubes. If, for instance, a short conical mouthpiece be put into a pipe at a certain point in its length, it will dam up the water flowing through the pipe, and the water will discharge under the head thus artificially produced, thus increasing its velocity. Then, to restore the velocity of the water to its original degree, the principle of the Venturi diverging tube, or of the Boyden diffuser, is resorted to, wherein the water, by being caused to pass through a long diverging cone is brought back again to its original cross section,—all this being superimposed on the hydraulic conditions as they existed in the pipe at the outset. Then the artificially-produced head so acts on the short, conical mouthpiece referred to that the difference in pressure resulting gives a measure of the quality of water passing, while the rest of the arrangement, with the long diverging cone, takes care that no serious loss of head results. The meter itself, with its accompanying register, is an elaborate and highly interesting mechanism, the details of which are not pertinent to an understanding of the principle upon which the water indictor, as used on the cooling coils in the powerhouse at Canyon Ferry, is based.‡

*THE JOURNAL Volume XII, pages 103 and 242.

*See *Cassier's Magazine*, Volume XV, page 411, March, 1899; also *Transactions* of the *American Society of Civil Engineers*, November, 1887.

†See THE JOURNAL, Volume V, page 109, March 1898.

‡The principles of the Venturi water meter are fully detailed with diagrams in the *Steam-Electric Magazine*, Volume III, page 69, March, 1899.

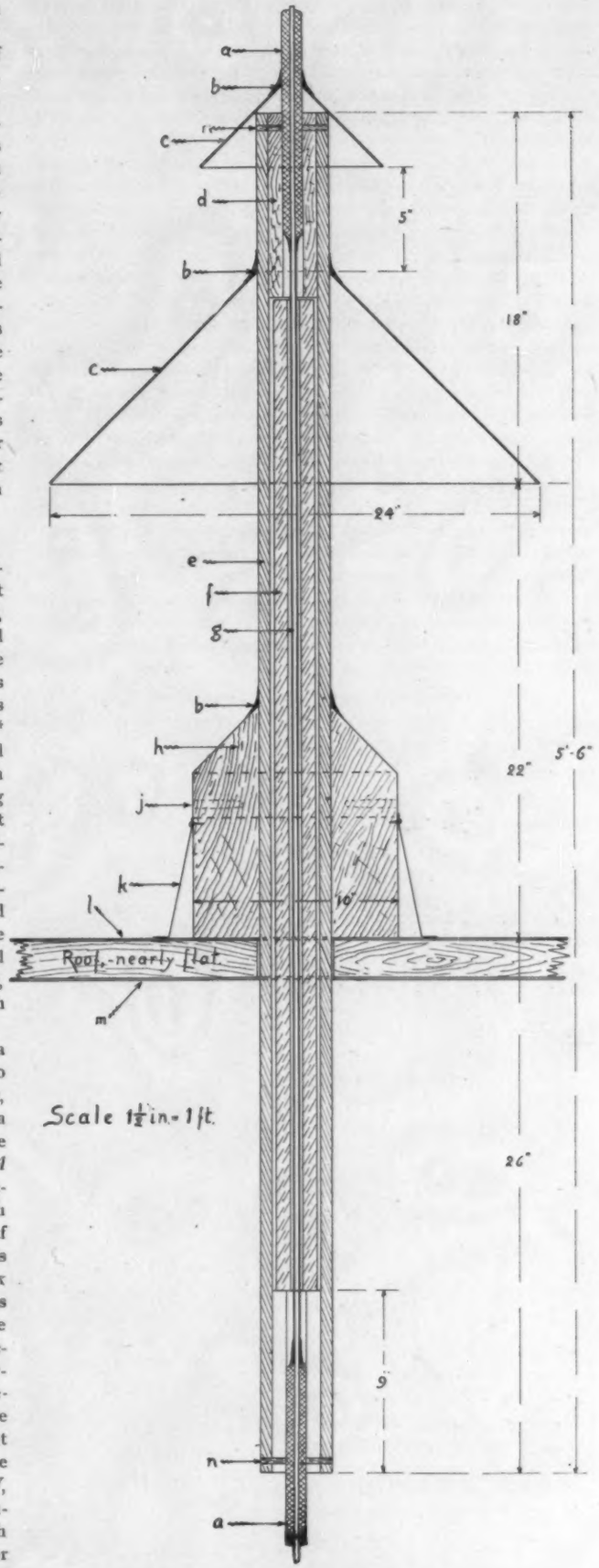
The arrangement of this water indicator, as installed at Canyon Ferry, is shown in the accompanying photo-engraving, wherein the transformer appears in the background behind the system of piping constituting the indicator. Water is taken from the forebay, through the wall to the left, by means of a one and one-half-inch pipe—the upper horizontal pipe shown in the half tone,—while the outlet, which also forms the suction of the siphon, is through the two-inch pipe running horizontally along the bottom of the engraving. The inlet pipe branches through a Y connection into two one-inch pipes which are separately controlled by globe valves, as shown, and are then continued through the transformer case as double cooling coils, after which they are united into the outlet by means of the second Y connection and the Venturi tube, as shown. In this tube the main diameter is approximately one and one-half inches, the minimum diameter is about three-eighths of an inch, while its length over all (exclusive of the gage) is thirteen inches. The method of connecting the gage to the tube is so clearly shown as to require no further explanation, beyond the statement that the V-shaped gage glass is filled half full of mercury and that the restriction in the diameter of the Venturi tube is such that a flow of one cubic foot of water per minute through the Venturi tube will show very close to ten inches of mercury in the gage glass.

AN EXTREME HIGH TENSION ROOF INSULATOR.

One of the startling innovations in the Canyon Ferry powerhouse, consists in the method devised for carrying 50,000-volt lines out of the station without recourse to air spaces, sewer tile, plate glass, or other means in common usage. The system devised is undoubtedly an elaboration of that which has been in use for several years on the 15,000-volt lines entering the Los Angeles substation of the San Gabriel Electric Company, and the details of which are already familiar to the readers of THE JOURNAL.* So perfectly has the plan proven in practice in the San Gabriel plant, as well as during the ten months of service in the Canyon Ferry plant, that no hesitation is felt in commending it as being far preferable to the older methods of entering and making exit of high tension wires from station buildings. Though its advantages are obvious, it may be pointed out that the roof insulator, as here described, always remains clean; it affords no opportunity for the collection of dust on neighboring parts; it is air and water proof, and in brief, it preserves a high insulation upon the line from the moment it leaves the transformer until it is well outside of the building. More than this, as stated, it is thorough, and it is believed to be absolutely reliable for the extreme high voltages used in heavy long distance transmission work.

Reference to the accompanying sectional drawing will enable a thorough understanding of the component parts of the device to be conveyed. The high tension wire used is of No. 4 B. & S. gage, medium, hard drawn copper, and this wire is protected by a rubber covering three-eighths of an inch in thickness at the points where it enters and leaves the roof tube as shown at *A* and *A*. The intermediate insulation on this wire over the section shown at *G* is also of rubber, but it is one-thirty-second of an inch in thickness. The principal strength of the tube consists of a tubular cylinder of Manila paper rolled in linseed oil, which is designated in the drawing as the letter *E*. This tube is sixty-six inches in length, its diameter is three and one-half inches, and as the hole within it measures two and three-eighths inches in the clear, hence the walls of the tube have a thickness of one and one-eighths inches. At each end of the tube there is fitted the paraffine wood filler *D*, while the space within the Manila tube between these respective wood fillers is completely occupied by the glass tube *F*, which is two inches in diameter by forty-eight inches in length, and is of five-eighths of an inch bore. The wood-fillers are held in place by the wooden pins shown at *N*, and strength is added in supporting the tube through the instrumentality of the split bushing of pine boiled in paraffine, which is designated by the letter *H*, this split bushing being further secured by the wooden clamping pins shown at *J*.

*See Volume XII, page 89, May, 1902.



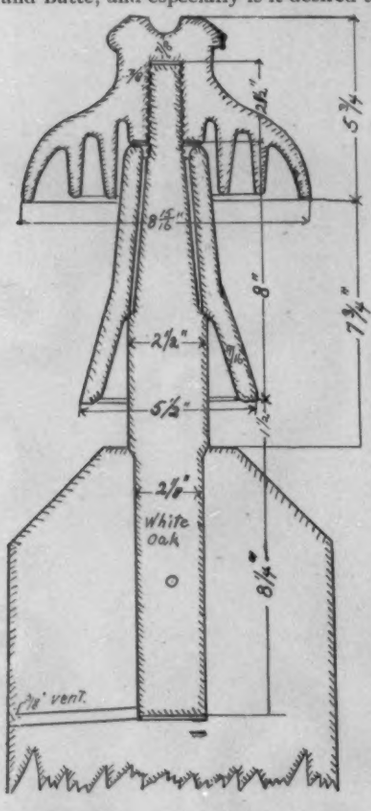
SECTION OF THE 50,000-VOLT ROOF INSULATOR OF THE MISSOURI RIVER POWER COMPANY

This tube leads through a roof that is nearly flat, in the manner shown in the diagram. Its lower side, which forms the ceiling of the station, is sheathed with asbestos building paper having a thickness of about one-sixteenth of an inch, while the upper side, which is, of course, exposed to the elements, is tinned. Additional protection from the weather is afforded through two paper cones designated as *C* and *C*, respectively. These cones consist of shellacked paper dipped in linseed oil, the smaller cone having a diameter of six inches while that of the larger one is twenty-four inches, and these are taped respectively in the manner shown at *B* and *B*. A galvanized iron flashing shown as *K* connects the split pine bushing to the roof so thoroughly as to preclude possibility of leakage. Other dimensions necessary to a thorough understanding of the construction of the device are shown on the drawing.

During the writer's visit to the Canyon Ferry plant in October last, the raising transformers of the station were stated to be delivering 57,000 volts to the line for power transmission to Butte, sixty-five miles distant. The line was quiet in every sense, for it was not disturbed even by the hum of static discharges, as commonly occurs in other lines which are operated at less voltage. Naturally, however, the line commanded every deference, which was emphasized by the fact that each of the roof tubes here described (there are six of them in all), was boxed-in by a wind break made of plain boards, the inclosure being five feet by six feet in size, by thirty-eight inches in height. These boxings were painted with red roof paint after the manner in which the tin roofing was covered. It may be added that the sectional plan herewith presented, is drawn to the scale of one and one-half inches to the foot, which will further facilitate a comprehension of its construction.

THE GERRY 50,000-VOLT INSULATOR.

Information is frequently sought concerning the type of insulator used on the high voltage transmission between Canyon Ferry and Butte, and especially is it desired to know the dimensions of the insulator and the success which has attended its use. As is generally known, the insulator is made of glass, produced by the Hemingray Glass Company of Covington, Ky., and its outlines and dimensions are as given in the accompanying sectional sketch, which is from the original drawings of Mr. M. H. Gerry Jr., chief engineer and manager of the Missouri River Power Company, and who designed the insulator.



In view of the completeness of the drawing and the appearance thereon of all dimensional data, a detailed description of this remarkable insulatior is unnecessary, beyond stating that it, together with its tapered glass sleeve, is all glass, non-cemented. It is stated that these insulators have proven to be absolutely reliable when in operation under 50,000 volts, and that the only defect which has occurred in their design rested in the belief that it would have been better to have given more body to the walls supporting the cap of the insulator at the section of the horizontal plane of the top of the pin, where a thickness of seven-eighths of an inch is shown. This belief is held for the reason that several—probably half a dozen—caps have broken off at the point stated, which would indicate slight structural weakness at that point. Were a new lot of insulators to be ordered the only change which would be made in the specification for them would be in the direction of increased strength in the body of the insulator supporting the cap.

One further notation: The ratio in which the transformers are wound is 552½ to 50,000. The generator voltage was stated to be 630 volts, which would give a line potential of approximately 57,000 volts. The weather was clear, cold, dry and crisp.

THE HEWITT VAPOR LAMP AND CONVERTER.

IF first impressions are to be substantiated by subsequent developments, the name of Hewitt will take rank along with those of Roentgen and Marconi in the evolution of startling electrical inventions, for it is certain to the engineering mind at least, that the invention by Mr. Peter Cooper Hewitt of his mercury vapor lamp, and of his so-called static converter, which is an outcome of it, is as replete in scientific interest as were the inventions of the Roentgen ray and of wireless telegraphy. It is only within the past month that satisfactory details regarding Mr. Hewitt's inventions have been made public, and although the static converter appears to be more promising as to commercial work than the vapor lamp, a description of the former should be given first, for, as intimated, it is the direct forerunner of the converter.

THE HEWITT VAPOR LAMP.

From descriptions which are at hand,* the Hewitt lamp consists of a glass tube of any desired shape or size, in the bottom of which rests a pool of mercury, and to the top of which is sealed in, through proper connections, a simple iron electrode. The air within the tube is rarified, which permits the tube to fill with mercury vapor, and thus constructed it is available for use when operated on a direct current, which may be of any potential from fifty volts up to 500 volts. Its candle-power may be made to vary from sixteen candle-power up to 500 candle-power or more according to the size of the tube and the energy applied to it, and the operation of the lamp is similar to that of constant potential arc lamps, in that it burns with greater satisfaction when connected in series with a resistance causing a drop of say 15 per cent. or 20 per cent. This method of connection regulates the light in the tube so that it burns with absolute steadiness under variations in pressure running as high as 10 per cent. The lamp is, however, not self-starting, for materially higher voltage than necessary for operation is required to break down the high resistance of the vapor in the tube when it is cold. But the easy and simple method by which Mr. Hewitt has overcome this apparent defect commands admiration. It consists simply in discharging the energy of a spark coil through the tube which lights it momentarily, and when once lighted by this means the potential of the direct current source of supply breaks through the path thus opened and the tube springs into service. It will maintain practically full candle-power indefinitely without material depreciation, and in this it differs to an extraordinary degree from other forms of electric lamps, for obviously it possesses neither filiment nor carbon to wear out. The source of luminosity is the vapor of mercury, which is constantly replenished from the pool of mercury at the lower electrode of the lamp. Its inventor recommends, however, that the inner surface of the tube be cleaned every 1200 or 1500 hours, in order to clear it of any film-like coating of mercury which may have occurred to the diminution of its candle-power.

The Hewitt lamp bears no resemblance to the Nernst lamp,

*Electrical World and Engineer, Volume XLI, page 121, January 17, 1903; The Electrician, Volume L, page 509, January 17, 1903; Electrical Review (London), Volume LII, page 89, January 16, 1903; and The Electrical Engineer (London) Volume XXXI, N. S, page 87, January 16, 1903.

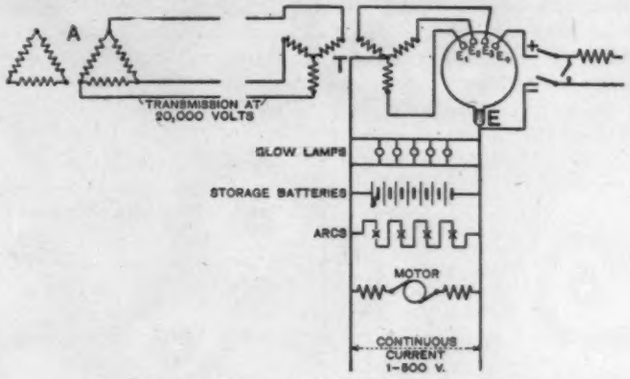
unless it be a negative one, for while the latter will not operate satisfactorily on a direct current service, the Hewitt lamp will not operate on single phase alternating current service. Owing to the peculiar characteristics of its vapor column the current can pass only in one direction, in consequence of which the alternation on one side of the zero line only will traverse between the electrodes. This cuts off all alternations of the opposite sign, which becomes inert in that they absorb no energy. In this the Hewitt lamp bears a striking resemblance to the electrolytic rectifier, which may be described as an electric check valve. From this it follows that if a single phase alternating current be thrown upon the Hewitt lamp, the instants of revival of polarity permit the initial resistance of the vapor column to reassert itself, in consequence of which it will not relight.

The Hewitt lamp is stated to have an efficiency of two candles per watt, and when it is remembered that an efficiency of five candles per watt constitutes perfection, it will be seen that the Hewitt lamp possesses qualifications in point of economy that are unknown to any other artificial illuminant. The current consumed in the tubes may be varied from two-tenths of an ampere to twenty amperes on any direct current service, and the lamp may be burned in series or parallel as desired. The particularly unfavorable feature of the light produced rests in the fact that it is composed almost entirely of actinic or chemical rays, while at the same time it has an utter absence of red rays. This means that colors which appear yellow in daylight take on a greenish hue when viewed in the light of the Hewitt lamp. Red colors simply appear to be black, and this feature it presents will put a serious commercial handicap upon the universal use of the new lamp. It is maintained that the lamp is suitable for out-door lighting, for office work and for factory work, or in tunnels and mines, and that it is particularly suited for portrait photography, for blue printing and other lines of industry which demand a light that is particularly rich in chemical rays.

THE HEWITT CONVERTER.

The Hewitt rectifier, or "static converter," is doubtless an important discovery in relation to the general distribution of electric current for light and power purposes. It was evolved by Mr. Hewitt from his observations of certain phenomena in connection with his mercury vapor lamp, upon which its principles of operation are based.

In its general construction it somewhat resembles his vapor lamp, and it is even possible to combine the two, obtaining the brilliant mercury vapor light and also continuous current for power. The invention may be described as follows:—A vacuum tube or bulb is supplied with a positive electrode for each phase of the alternating current, which successively permits the positive alternations of the current to flow to a single negative electrode common to the several positives. Owing to the peculiar characteristics of the vapor column as a conductor, the current can pass, as stated, in only one direction, and in consequence the alternations on one side of the zero line only will traverse between the electrodes. The alternations of opposite sign are cut off, and become inert in that they absorb no power. As at present developed, the converter consists of a large glass bulb with a small quantity of mercury (E), in the figure, acting as the negative electrode. There are also four positive electrodes, E_1, E_2, E_3, E_4, one for a starting continuous current and three for the respective phases of the alternating current. When the continuous current is switched on a glow appears at one of the positive electrodes, and the bulb acts precisely as though it were an ordinary mercury vapor lamp. Then one phase of the alternating current is switched on and another electrode glows, and when the switches controlling the other two phases are closed all four electrodes work. The continuous current may then be switched off, and the converter will continue to work with three-phase alternating current only. If, however, the voltage is allowed to fall below a "critical point," the rectifier ceases to work, and will not recommence until the necessary electromotive force has been applied at the terminals. For this reason, as stated, it will not work on a single-phase system, as the pressure falls during the alternations and the inital resistance reasserts itself. With a polyphase system the electromotive force never falls to the "critical point," and, therefore, the rectifier works continously.



CONNECTIONS FOR HEWITT MERCURY VAPOR RECTIFIER

The coverter may be used on all potentials between 100 and 1,000 volts, and can, without further development, be made for all capacities up to 100 amperes. Several converters, properly arranged, can be operated in parallel. The efficiency is very high, the only loss in power being due to a constant drop of fourteen volts in the bulb. Consequently, at 140 volts the loss is 10 per cent., at 700 it is 2 per cent., and at 1,000 only 1.4 per cent.

THE "NODON ELECTRIC VALVE."

In this connection it is interesting to note the most recent progress in the development of electrolytic rectifiers, and one which, it is claimed, fills the requirements of a substitute for the rotary converter on the motor-generator is found in the recent invention of M. Nodon, a French engineer. This rectifier is described* as one which cuts off one-half of a complete period of alternation, thus changing the alternating current into a uni-directional pulsating current. This, however, it only does when a single cell (Figure 1) is used. If it be desired to make use of the half of the curve below the zero line, recourse must be had to a scheme of connections and grouping of cells (Figure 2), which will be fully referred to later.

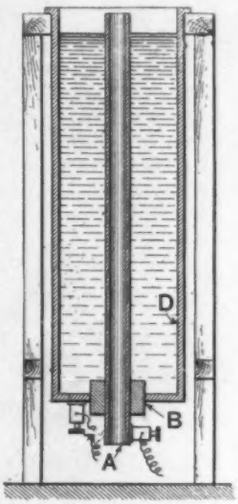


FIGURE 1

The rectifier, which, as a development of the apparatus discovered by Pollak and Graetz, is extremely simple in design, and consists merely of a hollow cyclinder A (Figure 1) of zinc and aluminum alloy, immersed in a solution of ammonium phosphate. A containing vessel, D, of iron, forms the other electrode, from which A is insulated by the rubber plug B.

On starting the "valve," as it is called by M. Nodon, it merely acts as a liquid resistance, and does not choke back one-half of each alternation. This, however, only lasts for a very brief time, and after a few minutes a film commences to form on the surface of the aluminum electrode. It is this film which possesses such valuable properties and permits current to pass in one direction only—*i. e.*, from D to A.

Obviously, the fact that only half the energy can be utilized is a disadvantage, but it is possible to adopt the scheme of connections shown in Figure 2, and by using four cells, convert all, or nearly all, the alternating current into continuous current. This

*The *Electrician*, Volume L., page 551, January 23, 1903.

grouping is known as the Leo Graetz method; by following out the connections it may be seen that both semi-phases are utilized.

When used in conjunction with polyphase systems the matter becomes rather more complicated, and it is necessary to employ a number of cells or valves equal to twice the number of wires used in distribution; for instance, six would be required on a three-wire three-phase system. Each cell may be used for rectifying current at from fifty to 140 volts, but when the voltage exceeds the latter figure, two or more cells must be connected in series, allowing 140 volts, as a maximum for each cell.

Regulation in connection with those valves having a capacity of more than four kilowatt may be effected either by a choking coil on the alternating current side of the apparatus or by the adjustment of insulating sleeves which may be made to cover or expose the aluminum-zinc cylinders at will. It is said that the efficiency of the cell remains practically constant for all loads and seldom falls below 75 per cent. The loss consists in a reduction of 10 to 12 per cent. of the electromotive force and of a leakage of alternating current within the rectifier, corresponding to from 10 to 12 per cent. of the energy utilized. This energy is dissipated in heat, which is liberated within the cell, and causes the temperature of the latter to rise to about 50 degrees C., after which radiation from the metallic casing prevents a further excessive rise. The adjustment of the insulating sleeves over the aluminum electrodes may be effected either automatically or by hand. The frequency, within ordinary limits, of the applied voltage, appears to have no effect on the efficiency of the apparatus. Figure 3 is a curve showing the action of the valve when charging accumulators. By making the aluminum cylinders hollow, and providing a fan underneath the cells, a strong cooling draught is sent quite through them, thus preventing any excessive rise of temperature. The current-density is calculated at about five amperes per square decimeter of active surface of aluminum.

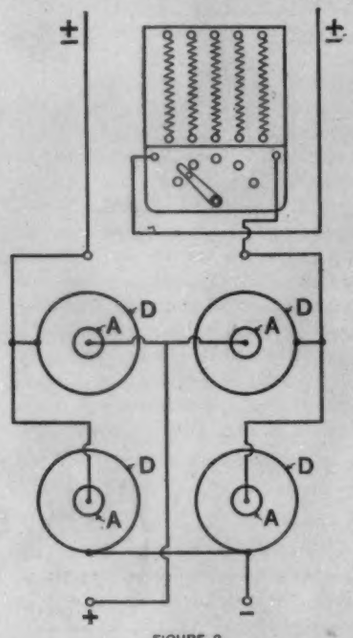


FIGURE 2

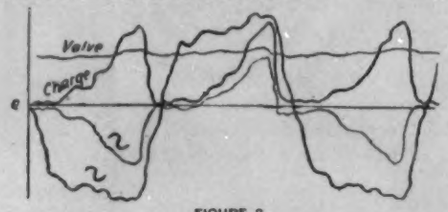


FIGURE 3

Mr. Nodon has also designed an electrolytic condenser on the same principle as his rectifier, which possesses a considerable capacity for its size, and should be useful for starting alternating-current motors and similar purposes. The rectifier is now being put on the market in sets of cells large enough to deal with ten kilowatts at the maximum voltage of 140. The selling price in London of a complete set of four cells having a capacity of five kilowatts for a single-phase circuit is $150, which price would appear to be almost prohibitive in the case of motors connected to single-phase circuits, but as the construction of the "valve" is simple, it may safely be inferred that the selling price would be considerably reduced should there be a demand for this apparatus.

INDUSTRIAL.

MESSRS. CHAS. C. MOORE & CO.

MESSRS. CHAS. C. MOORE & CO., the well known engineers of San Francisco, have recently leased for a term of years much larger and better equipped offices and salesrooms than they now occupy at 32 First Street. The new quarters will be located in the Union Foundry Block, on the northeast corner of Mission and First streets, San Francisco, and the change has become necessary because of the large increase in activity among the power, electric lighting, pumping and mining industries of this coast. The change will be made about March 1st. These new offices will bring together the various departments which have hitherto been compelled to occupy several different buildings.

As is well known this firm is engaged in designing and constructing complete power, lighting, mining and pumping plants, and it has executed some of the most important work on the Pacific Coast. Its latest acquisition is a newly established department for the sale and construction of complete mining and smelting plants, for which purpose it has recently concluded arrangements to represent the Holthoff Machinery Company, of Cudahy, Wis., on the Pacific Coast.

NEW BULLOCK BULLETINS.

NEW bulletins, according to numbers expressed in parentheses, have just been issued by the Bullock Electric and Manufacturing Company of Cincinnati, upon the following subjects: Bullock Motors applied to Brewing Machinery (No. B 45); the Bullock Electric Power System for Operating Newspaper Presses (1000); Type "N" Direct Current Multipolar Motors (1002); Marine Lighting and Power Sets (1003); Railway Generators (1006); Variable Speed Motors (1007). the Bullock System of Control for Variable Speed Electric Motors by Multiple Voltage (1009); the Electrical Equipment of a Modern Shipyard (1010); Bullock Motors in Cold Storage Plants (1014). The company has also issued an attractive pamphlet entitled "The Man With the Hoe—Electrically Driven," which tells about the satisfaction which has been derived from the use of scores of Bullock "teaser" equipments in driving Hoe and other great newspaper presses.

For copies of these bulletins write to the company at Cincinnati, or to the Wagner-Bullock Electric Company of California, 519 Mission Street, San Francisco.

AN UNWARRANTED RUMOR DENIED.

A STATEMENT which is current to the effect that the Stanley Electric Manufacturing Company has sold out to the General Electric Company is officially declared to be unauthorized. It is true that negotiations for a change of ownership of control of the Stanley company are pending, but in this connection it should be stated that, notwithstanding all the newspaper reports, the control of the Stanley company has never passed into the hands of William C. Whitney. The plan to increase the capital stock of the company to $10,000,000, notice of which was announced in these columns last month, has not been abandoned, as some reports have made it appear, and the permanency and enlargement of the works at Pittsfield is one of the details agreed upon in any event.

PERSONAL.

MR. GEORGE H. GIBSON has resigned his position with the Westinghouse Companies' Publishing Department of Pittsburg, Pa., to accept a position with the B. F. Sturtevant Company of Jamaica Plain Station, Boston, Mass., the well-known manufacturers of blowers, heating, ventilating and forced-draught apparatus, electrical machinery and steam engines. Mr. Gibson was formerly a member of the editorial staff of the *Engineering News* of New York City, and is a graduate of the Engineering School of the University of Michigan.